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of
Education

Ontario

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Curriculum Guideline

Science

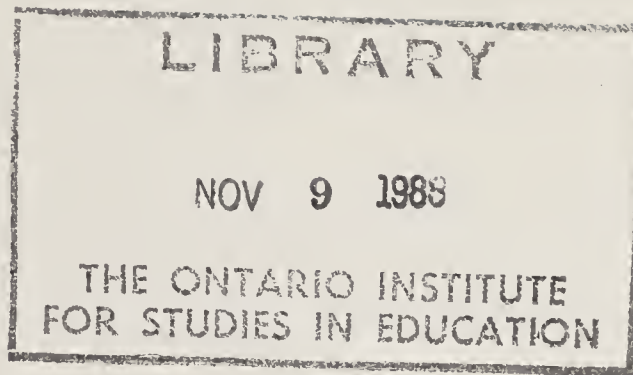
Intermediate and
Senior Divisions

1988

Part 9

Applied Biology and
Applied Chemistry

Grade 11, General Level



Introduction	3
The Parts of the Guideline	3
Policies and Features That Apply Across the Science Program	3
The Science Curriculum Continuum	5
Compulsory and Prerequisite Courses	5
Curriculum Emphases	5
Student Activities	5
Safety	6
Sensitive Issues	6
Locally Designed Units	6
Evaluation of Student Achievement	6
Cross References	6
Particular Features of the Applied Biology and Applied Chemistry Courses	7
Units of Study and Their Time Allocations	7
Some Suggestions for Teaching the Applied Biology Course	7
Some Suggestions for Teaching the Applied Chemistry Course	8
Applied Biology, Grade 11, General Level (SBA3G)	9
Core Unit 1: Dietary Input	10
Core Unit 2: The Alimentary and Excretory Systems	12
Core Unit 3: The Communication Network – Sensory Organs	14
Core Unit 4: The Respiratory and Cardiovascular Systems	17
Core Unit 5: Genetics and Reproduction	19
Core Unit 6: Waste Management	21

Optional Unit 1: Home Gardening	24
Optional Unit 2: Skin	26
Optional Unit 3: Bones and Muscles – Body Support	28
Optional Unit 4: Mammal Dissection	30
Optional Unit 5: Humans and the Environment	33
Optional Unit 6: Behaviour and the Central Nervous System	35
Optional Unit 7: Locally Designed Unit	38

Applied Chemistry, Grade 11, General Level (SCA3G) 39

Core Unit 1: Qualitative Analysis	40
Core Unit 2: The Structure of Matter	42
Core Unit 3: Properties of Substances	44
Core Unit 4: Chemicals in Action	47
Core Unit 5: Acids and Bases	49
Optional Unit 1: The World of Carbon Chemistry	52
Optional Unit 2: The Chemistry of Consumer Products	54
Optional Unit 3: Metallurgy	56
Optional Unit 4: Nuclear Chemistry	58
Optional Unit 5: Locally Designed Unit	60

Appendixes 61

A. Science Courses and Their Course Codes	62
B. The Table of Contents of Part 1	63

Introduction

The Parts of the Guideline

This document is Part 9 of a fifteen-part curriculum guideline that outlines the science program for the Intermediate and Senior Divisions in Ontario schools and describes the science courses that can be offered (see the list of courses and their course codes in Appendix A). The term *guideline* refers to the entire set of fifteen parts.

This part must be read and implemented in conjunction with Part 1, *Program Outline and Policy*. When implementing the courses that are described in this document, teachers are to incorporate the many policies and features outlined in Part 1, which will enable them to interpret the overall intent and expectations of the Ministry of Education in the science program. The table of contents for Part 1 is given in Appendix B at the end of this document so that the reader may have ready access to the list of chapters and topics therein.

The provincial science program for the Intermediate and Senior Divisions comprises the courses described in Parts 2 to 15. These come under the framework and policy set forth in Part 1. The entire science guideline consists of the following fifteen parts:

- Part 1: Program Outline and Policy
- Part 2: Science, Grades 7 and 8
- Part 3: Science, Grades 9 and 10, General Level
- Part 4: Science, Grades 9 and 10, Advanced Level
- Part 5: Science, Grades 9 and 10, Basic Level
- Part 6: Science, Grades 11 and 12, Basic Level
- Part 7: Environmental Science, Grades 10 to 12, General Level

Part 8: Environmental Science, Grades 10 and 12, Advanced Level

Part 9: Applied Biology and Applied Chemistry, Grade 11, General Level

Part 10: Applied Physics and Technological Science, Grade 12, General Level

Part 11: Geology, Grade 12, General and Advanced Levels

Part 12: Biology, Grade 11, Advanced Level, and the OAC

Part 13: Chemistry, Grade 11, Advanced Level, and the OAC

Part 14: Physics, Grade 12, Advanced Level, and the OAC

Part 15: Science in Society, OAC

The chart on the next page indicates the twenty-eight science guideline courses that may be offered in Grades 7 to 12 and at the OAC level.

Policies and Features That Apply Across the Science Program

Part 1 of the guideline specifies a great number of the policies and features that are to be integrated into the design of the science program in the Intermediate and Senior Divisions. There are too many of these to describe them in full in each of Parts 2 to 15, but the following points will give the reader some idea of the scope that is involved. They include:

- ▶ information about the science credits that are required for the earning of the Ontario Secondary School Diploma;
- ▶ a list of science courses that are prerequisite to other science courses;
- ▶ the policy regarding mandatory student activities in the science laboratory;
- ▶ a list of the aims of the science curriculum and the various emphases that may be used to blend these aims with scientific content;
- ▶ policy governing time allocations for units of study and the order in which core and optional units may be taught;
- ▶ stipulations about locally designed units;
- ▶ suggestions about preferred routes that students might take through the science program in a secondary school;
- ▶ recommendations related to exceptional students, individualized instruction, life-management skills, career awareness, the role and evaluation of language in science courses, and a balanced perspective on the role of both girls and boys in science;
- ▶ recommendations on the introduction and handling of sensitive issues;

Authorized Science Guideline Courses,
Intermediate and Senior Divisions

.....			
Grade 7	Science		
.....			
Grade 8	Science		
.....			
	Basic Level	General Level	Advanced Level
Grade 9	Science (SNC1B)	Science (SNC1G)	Science (SNC1A)
.....			
Grade 10	Science (SNC2B)	Science (SNC2G)	Science (SNC2A)
		Environmental Science (SEN2G)	Environmental Science (SEN2A)
.....			
Grade 11	Science (SNC3B)	Applied Biology (SBA3G)	Biology (SBI3A)
		Applied Chemistry (SCA3G)	Chemistry (SCH3A)
		Environmental Science (SEN3G)	
.....			
Grade 12	Science (SNC4B)	Environmental Science (SEN4G)	Environmental Science (SEN4A)
		Geology (SGE4G)	Geology (SGE4A)*
		Applied Physics (SPA4G)	Physics (SPH4A)
		Technological Science (STE4G)	
.....			
OACs	Biology (SBI0A) Prerequisite – Biology (SBI3A) Chemistry (SCH0A) Prerequisite – Chemistry (SCH3A) Physics (SPH0A) Prerequisite – Physics (SPH4A) Science in Society (SSO0A) Prerequisite – One of: Biology (SBI3A) Chemistry (SCH3A) Environmental Science (SEN4A) Geology (SGE4A)* Physics (SPH4A)		
.....			

*Since the Grade 12 advanced-level geology course described in the guideline (see Part 11) may be taught under the aegis of a geography department as Geology (GGE4A) – note the course-code change – then either Geology (SGE4A) or Geology (GGE4A) may count as a prerequisite to Science in Society (SSO0A).

- ▶ specific suggestions about resources for the teaching of science;
- ▶ ideas about different modes of delivering science courses, including the co-operative education mode;
- ▶ policy pertaining to the significant role to be played by measurement and metric units in science courses;
- ▶ stipulations related to the treatment of symbols, significant digits, and mathematical problem solving;
- ▶ recommendations concerning the roles to be played by calculators and computers in science courses;
- ▶ specific directions about safety;
- ▶ policy and principles pertaining to the evaluation of student achievement;
- ▶ policy regarding differences in the treatment of science courses at the three levels of difficulty;
- ▶ many suggestions about implementing the science program.

It cannot be emphasized strongly enough that teachers of science must integrate the policy and recommendations outlined in Part 1 with the teaching of science and cannot simply rely on the course descriptions given in Parts 2 to 15 of the guideline.

The Science Curriculum Continuum

By the time students have reached the Senior Division, they will have experienced first a *unified* approach in the Primary and Junior Divisions, in which science is related to a number of other subject areas, and then a *diversified* approach to a mosaic of science disciplines – biology, chemistry, physics, and environmental science – in the Intermediate Division. In the Senior Division they are provided with a *specialized* approach, in which the science courses deal with a single discipline at a time.

Although these approaches – unified, diversified, and specialized – provide different ways of dealing with the subject, the intention is to ensure that there is a continuum throughout the years. The two general-level courses in biology and chemistry build on the physical and biological science units of the general-level courses in the Intermediate years. For this reason teachers should be aware of the subject matter contained in the Intermediate Division courses and of the way in which the Senior chemistry, biology, and physics courses relate to one another.

In all science courses the core units and the prescribed number of optional units, if any, are to be included. The time allocation for each unit of study should act as a guide in helping teachers devote an appropriate amount of time to each of the units in a course. This is important in view of the continuum from one course to another and to postsecondary science programs.

Compulsory and Prerequisite Courses

In the secondary school program, two science courses are required among the compulsory subjects that are necessary for the earning of the Ontario Secondary School Diploma. It is, therefore, anticipated that most of the students who enrol in the Senior Division general-level biology or chemistry course will have taken Grade 9 and 10 science, also at the general level.

Curriculum Emphases

It is recommended that teachers organize each of the courses described in this document around a particular curriculum emphasis or set of emphases. Such emphases give the curriculum a special focus that can be introduced in addition to the content and processes outlined in the courses. This approach is discussed in subsection 3.4, “Curriculum Emphases – Blending Curriculum Aims With Content”, of Part 1 of the science guideline. A list of emphases is given in table 2 of that subsection. These emphases will enhance the development of the science courses described in this document. A particular emphasis that is stressed throughout an entire course or for one or more units at a time needs to be highlighted so that it becomes a focal or integrating theme.

Student Activities

In each unit of study there is a section entitled “Student Activities”. This section indicates the *mandatory* laboratory activities required of students. Teachers may substitute *equivalent* laboratory activities where appropriate. Those activities that are actually to be performed by students themselves are marked with asterisks. If time and circumstances permit, the teacher should encourage students to do some or all of the unmarked activities as well. However, such activities may be demonstrated by a student or the teacher or may be discussed in conjunction with a textbook, film, or computer program, or another learning material used as a resource. In any event, the scientific concepts and principles related to such unmarked activities and identified in the objectives of the unit of study shall be considered to be part of the prescribed course.

Generally, the best approach to the teaching of science is to ensure that the content develops directly from related student activities. In each unit of study the skills and processes of scientific work should be presented as the central component, from which the subject matter, applications, and implications emerge.

Safety

Safety awareness must be developed in all science students. Constant attention to accident prevention is to be stressed in all student activities and teacher demonstrations in the laboratory. Section 9, "Safety", in Part 1 of the science guideline contains the following comprehensive subsections:

- ▶ Safety in the Laboratory
- ▶ Some Recommended Safety Procedures
- ▶ Animal Care in Science Courses
- ▶ The Safe Use of Plants

In each unit of study, section 6, "Safety Considerations", acts as a reminder of some of the safety features that pertain to the unit in question. General reference, however, should constantly be made to the safety section in Part 1. In addition schools must always remain on the alert in regard to safety and must maintain an up-to-date safety-awareness program. For example, this guideline does not outline all precautions regarding field trips.

Sensitive Issues

The curriculum outlined in this science guideline places a distinct emphasis on the science-technology-society connection. For this reason scientific applications and societal implications are mandatory components of each unit of study. In addition, Part 1 of this guideline underlines the need to incorporate morals/values education into science courses. Undoubtedly, this will give rise to the discussion of some sensitive issues.

Such discussions are important. Generally, they should be focused and should provide an open forum for the expression of different viewpoints. In this regard teachers of science are urged to familiarize themselves with section 10, "Values in Science Education", of Part 1 of the guideline and to pay particular attention to the principles to be observed when dealing with sensitive issues in the science curriculum. These principles are mentioned in subsection 10.2 of Part 1.

Locally Designed Units

Among the optional units in each of the courses described in this document is one entitled "Locally Designed Unit" (LDU). Such a unit is included to allow teachers, at their discretion, to introduce an appropriate new area of biology or chemistry not described in the guideline, to expand on previous units or topics by adding new work, or to use the time allocated to the LDU to extend the time allocations for the core units. (See also Part 1, subsection 5.5.)

Evaluation of Student Achievement

In each unit of study described in the courses outlined in this document, section 5, "Evaluation of Student Achievement", specifies certain items that must be included in students' term marks (exclusive of formal examinations) when their achievement is evaluated. In most units teachers are required to evaluate students' activities and related laboratory reports. However, the proportion of the mark assigned will vary from one teacher to another. In order that the experimental component of science be emphasized, the overall mark for an entire science course must include at least 15 per cent for the evaluation of student achievement in laboratory skills and reports.

Cross References

In the descriptions of each unit of study in the courses outlined in this document, cross references are provided in parentheses. These are included to provide some examples of the relationships that exist among the parts of the unit.

Particular Features of the Applied Biology and Applied Chemistry Courses

Units of Study and Their Time Allocations

The following charts provide an overview of the units of study in the Grade 11 general-level applied biology and applied chemistry courses. They also indicate the time to be allotted to each unit.

Applied Biology, Grade 11, General Level (SBA3G)

Units of Study	Time Allocations
<i>Core</i>	
1. Dietary Input	14 h
2. The Alimentary and Excretory Systems	15 h
3. The Communication Network – Sensory Organs	15 h
4. The Respiratory and Cardiovascular Systems	14 h
5. Genetics and Reproduction	14 h
6. Waste Management	14 h
	<u>86 h</u>

Units of Study	Time Allocations
<i>Optional</i>	
Two or three of:	
1. Home Gardening	12 h
2. Skin	12 h
3. Bones and Muscles – Body Support	12 h
4. Mammal Dissection	6 h
5. Humans and the Environment	12 h
6. Behaviour and the Central Nervous System	6 h or 12 h
7. Locally Designed Unit	6 h or 12 h
	<u>110 h</u>

Applied Chemistry, Grade 11, General Level (SCA3G)

Units of Study	Time Allocations
<i>Core</i>	
1. Qualitative Analysis	16 h
2. The Structure of Matter	16 h
3. Properties of Substances	17 h
4. Chemicals in Action	13 h
5. Acids and Bases	16 h
	<u>78 h</u>

Optional

Two of:	
1. The World of Carbon Chemistry	16 h
2. The Chemistry of Consumer Products	16 h
3. Metallurgy	16 h
4. Nuclear Chemistry	16 h
5. Locally Designed Unit	16 h
	<u>110 h</u>

Some Suggestions for Teaching the Applied Biology Course

This course is designed to introduce students to a study of human biology and deals with the input, internal processing, and output of the body. The impact of humans on the environment, in terms of both their waste and other human activities, is also considered in order to provide a balanced treatment of this area of study.

The input, processor, and output components of the human body provide a framework for the course. Students will examine the quality and quantity of the input to the body, the efficiency of the body's processing and communication mechanisms, and the effectiveness of the treatment of waste materials prior to their returning to the environment.

Core units 1, 4, and 5 contain areas of potential overlap with courses in family studies and health and physical education. It is strongly recommended that representatives of the departments involved with the possible overlap in each school meet to co-operate in the planning of these units so that the various courses are complementary. This applied biology course should emphasize laboratory investigations and the basic biological knowledge that results from these investigations.

The first-aid components introduced in this course should emphasize an understanding of the biological principles that are the basis of the various techniques examined. It is highly recommended that demonstrations and instruction in first aid be left to *qualified instructors*. Students should not be expected to perform the various techniques.

The interrelationship between science and society is important in an applied-science course. The applications and societal implications sections of each unit are therefore important features of this course. Students must see the study of biology as a relevant, human endeavour. Students should be assisted in developing skills for thinking critically about the relationships between biological principles and environmental or societal issues.

It is intended that the overall evaluation of student achievement both reflect the primary emphasis on practical laboratory work and include other components as required.

Optional unit 5, "Locally Designed Unit", may be used to introduce a new area of biology not described in the guideline, to include new work that expands on previous topics in the course, or to extend the time allocations for the core units by an additional six or twelve hours.

Some Suggestions for Teaching the Applied Chemistry Course

This course is designed to introduce students to a wide variety of chemical applications in a practical laboratory setting. Students have the opportunity to work on relevant activities, developing laboratory skills that may be of use to them in future related careers.

Qualitative analysis is suggested as the first unit because it allows for a great deal of student activity and should immediately arouse student interest in chemistry. The unit may be used to review ideas relating to chemical change introduced in the Intermediate Division. The chemical reactions examined in this unit can act as examples in later units.

The topics in this course tend to be more interdisciplinary than those normally found in a traditional chemistry course. The activities are relevant and applied, while theoretical considerations play a less dominant role.

Fundamental chemical and mathematical concepts have been limited to those that are essential and applicable to the units that have been selected for study. More advanced concepts in chemistry are included in the Grade 12 technological science course. Molarity can be introduced in this course, where appropriate, but it is not a mandatory part of the course.

The interrelationship between science and society is important in an applied-science course. The applications and societal implications sections of each unit are, therefore, important features of this course.

It is intended that the overall evaluation of student achievement both reflect the primary emphasis on practical laboratory work and include other components as required.

Certain attitudinal objectives, such as (b) to (e), and skill objectives, such as (a), (b), and (e), in core unit 1 are applicable to the entire course, but are stated only in the first unit to avoid unnecessary repetition.

Optional unit 5, "Locally Designed Unit", may be used to introduce a new area of chemistry not described in the guideline, to include new work that expands on previous topics in the course, or to extend the time allocations for the core units by an additional sixteen hours. If new topics are introduced in a locally designed unit, care should be taken to avoid chemistry topics that are included in the first three units of Technological Science, Grade 12, General Level, unless students are unlikely to take this course.

Safety is of concern in nearly every chemistry activity. There are several generally accepted practices in the chemistry laboratory that should be recalled and checked in conjunction with each activity. Most of these can be found in section 9 of Part 1 of this guideline. Attention to these items is strongly recommended for student and teacher safety.

Applied Biology, Grade 11, General Level (SBA3G)

Core Units

Dietary Input
The Alimentary and Excretory
Systems
The Communication Network –
Sensory Organs
The Respiratory and
Cardiovascular Systems
Genetics and Reproduction
Waste Management

(86 hours)

Optional Units

Home Gardening
Skin
Bones and Muscles –
Body Support
Mammal Dissection
Humans and the Environment
Behaviour and the Central
Nervous System
Locally Designed Unit

(24 hours)

Core Unit 1

Dietary Input

Time: 14 hours

Some of the more fundamental and important decisions that people make each day are related to food and beverage consumption. Adolescents should develop an understanding of the ingredients of food and the role that these ingredients play in the functioning of the human body. They should understand the importance of selecting foods that provide for a balance of nutrients in the diet. The student activities should form the initial focus of this unit, and the appropriate content should then follow from each activity. The teacher should consult with teachers of family studies to ensure that the two programs are complementary and reinforcing.

This unit may be divided into topics such as the following:

- Ingredients in food
- Nutrient tests
- ▶ Vitamin C analysis

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a critical attitude towards the quality and quantity of the foods they consume (3c);
- b) an awareness that they will live healthier lives if they develop proper eating habits (3a);
- c) an appreciation that scientific experiments can provide information concerning the ingredients in foods (2a-2e);
- d) improved decision-making skills regarding appropriate food and beverage selection.

Skills. Students will have the opportunity to develop skill in:

- a) classifying both the nutrients and additives in food (2a);
- b) analysing foods for the presence of various nutrients (2b);
- c) controlling variables while measuring quantitatively the amount of vitamin C found in selected foods (2d);
- d) plotting a histogram indicating the amount of vitamin C in various fruits and vegetables and their juices (2d);
- e) keeping organized records of experimental work and daily food, drink, and energy consumption (2f);
- f) evaluating the quality of the food they consume and making suggestions for improvements, if necessary.

Knowledge. Students will be expected to:

- a) state the major biochemical nutrients in foods, for example, protein, carbohydrates, fats, water, vitamins, and minerals, and indicate their functions in the body (2b);
- b) name the basic chemical components of protein, starch, and fat; list food sources that are rich in each; and describe how they should manage these three components in their own food intake in order to attain a healthy, nutritious balance;
- c) describe the relationship between the way ingredients are listed on labels and their mass (2a);
- d) describe body requirements for a balanced diet based on biochemical needs and indicate how these might vary with different lifestyles;
- e) describe the importance of food fibre;
- f) compare the energy content of a variety of foods (2e);
- g) explain the effects of cooking and preserving on the nutrient content of foods (4e).

2. Student Activities

Students are to:

- *a) classify the ingredients in packaged foods on the basis of the information on the label (8a, 8b);
- *b) perform chemical tests to identify the presence of protein, starch, and sugar in various food samples (6a-6c);
- c) analyse a given unknown mixture for the presence of nutrients;
- *d) determine by experiment the amount of vitamin C in fruits, vegetables, and their juices (6c, 8c);
- e) use a calorimeter to determine the relative energy content of a variety of foods (6c);
- *f) analyse the lifestyle of one of their peers in a report based on a simulated record of the individual's daily food and energy intake and energy output (8e).

*See the subsection entitled "Student Activities" on page 5.

3. Applications

- a) A knowledge of food input and energy output can help people develop appropriate eating habits.
- b) Reading labels carefully may enable the individual to avoid consuming unwanted additives.
- c) By using criteria based on the results of scientific investigations in selecting and purchasing food, students should be able to make informed consumer decisions.

4. Societal Implications

- a) Increased awareness in society of the nutrient value of foods should result in a healthier population.
- b) Many health disorders can be controlled by diet (e.g., diabetes) or can be affected by diet (e.g., cancer).
- c) Most fad diets can cause serious long-term negative effects.
- d) Food additives such as salt may accentuate health problems in some individuals.
- e) The processing and preserving industry provides a variety of careers for people with knowledge and skills related to the analysis of nutrients in foods.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) laboratory work (e.g., analysis of food for vitamin C);
- b) ability to classify the ingredients in packaged foods;
- c) ability to organize their experiments and laboratory reports;
- d) ability to improve their food intake on the basis of their personal needs.

6. Safety Considerations

- a) Students should use protective eyewear when heating solutions.
- b) The indicators used for chemical tests should be handled with care.
- c) The food samples used in experiments should not be consumed and should be disposed of immediately after use.
- d) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) investigate some of the ingredients used in herbal medicines and remedies;
- b) list and compare various common food-preparation methods with respect to the ultimate nutritional value of the foods;
- c) do a library research project on a diet-related topic, such as obesity, anorexia nervosa, fad diets, food allergies, food additives, or health foods;
- d) use a computer program to evaluate their daily food and energy intake;
- e) examine and analyse the special diets required by persons with ulcers, gall-bladder problems, and high cholesterol levels;
- f) examine the procedures used by government laboratories to analyse and control foods sold on the market.

8. Some Teaching Suggestions

- a) The laws governing the listing of food ingredients on labels should be stressed.
- b) Students should be encouraged to bring a variety of food labels to the classroom. They should be given the opportunity to design their own classification system for the ingredients listed on the labels.
- c) Students should be made aware of experimental error by comparing the results of their vitamin C analysis with others.
- d) The ability of students to perform various laboratory skills should be evaluated during the laboratory activities.
- e) Students should be encouraged to keep accurate records.
- f) Students should be encouraged to evaluate critically their own food intakes.

Core Unit 2

The Alimentary and Excretory Systems

Time: 15 hours

The nutrients in the foods that we eat are digested and absorbed into the body, and the leftover wastes are excreted or eliminated. This unit focuses on an understanding of the components of the body that accomplish these functions and how these components work together. The results of student laboratory work can provide a basis for this understanding.

This unit may be divided into topics such as the following:

- ▶ The digestive system
- ▶ The excretory system

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation of the relationship of the structure of the digestive system of various organisms to their specific diets (2a, 2f);
- b) a concern regarding the need for the proper disposal and treatment of digestive and excretory waste;
- c) a curiosity about the role of stress in human body functioning and its relationship to lifestyle (4a);
- d) a questioning approach to the appropriate use of easily obtained medicines for digestive and excretory disorders (3c).

Skills. Students will have the opportunity to develop skill in:

- a) observing morphological adaptations, such as tooth structure and length of the digestive system, and describing the relationship of these to an animal's diet (2a);
- b) formulating hypotheses and controlling variables in an experiment examining enzyme properties (2b);
- c) interpreting observations that relate to the specific conditions under which enzymes break down macromolecules (2b, 2c);
- d) reporting investigations in a way that will enable others to repeat them;
- e) using dissection instruments and proper technique during the dissection of a vertebrate (2f);
- f) performing a simple acid-base titration (2g);
- g) measuring the quantities of materials required for simple titrations (2g).

Knowledge. Students will be expected to:

- a) describe the types, basic structure, and functions of human teeth (2a);
- b) describe and apply the methods of, and understand the need for, proper oral hygiene (2a);
- c) outline the cause, symptoms, and treatment (and possible prevention) of selected disorders of the digestive system (e.g., tooth cavities, gingivitis, periodontal disease, halitosis, gastric ulcer, hiatus hernia, heartburn, duodenal ulcer, diabetes, peritonitis, appendicitis, hepatitis);
- d) compare human dentition with that of other vertebrates (2a);
- e) state the location of the salivary glands and list the components and functions of saliva (2c);
- f) describe the optimum condition for the operation of some digestive enzymes, such as amylase or pepsin (2b, 2c);
- g) describe the structure and function of each of the following components of the digestive system: mouth, tongue, epiglottis, esophagus, stomach, intestine, liver, gall bladder, pancreas, appendix, rectum, anus (2f);
- h) describe the mechanics involved in swallowing and in peristaltic movement throughout the digestive tract (2f);
- i) describe how choking can occur and possibly be prevented, as well as know first-aid procedures to assist a choking victim;
- j) describe how substances such as alcohol, aspirin, and nutrients are absorbed through the stomach or small intestine (2d);
- k) state the function of bile (2e);
- l) identify the parts of the digestive system and excretory system seen in a vertebrate dissection (2f);

- m) describe the structure and function of the kidneys, ureters, urinary bladder, and urethra (2f);
- n) identify the major components of urine and describe the relationship of each to diet;
- o) outline the cause, symptoms, and possible treatment of urinary-tract infections and kidney stones;
- p) describe the effect of stress on the alimentary and excretory systems and suggest methods of coping with and reducing the stress level (8g).

2. Student Activities

Students are to:

- *a) observe the structure of human teeth by examining models or diagrams and compare this to the structure and function of the teeth of other vertebrates (8c, 8d);
- *b) design a properly controlled experiment to observe the effects of pepsin and hydrochloric acid on egg albumin under a variety of conditions (6a, 8a);
- c) conduct an experiment to investigate the conditions under which amylase digests starch and test the products of digestion with Benedict's solution, Fehling's solution, or a glucose test strip (6a);
- d) construct a model of the small intestine to illustrate how convolutions and villi increase the surface area of the small intestine for nutrient absorption (8c, 8f);
- e) demonstrate the process of emulsification by adding some commercially obtained bile to a layer of cooking oil on water (6a, 8e);
- *f) perform a vertebrate dissection to observe the parts of the digestive and excretory systems (6b, 8d);
- g) titrate various antacids with hydrochloric acid to determine the effectiveness of each (6a).

3. Applications

- a) A knowledge of the location and function of body components helps in the understanding of health and disease.
- b) Recognizing an abnormal condition gives the individual an opportunity to seek appropriate early treatment and relief.
- c) A basic knowledge of over-the-counter drugs specifically intended for digestive or excretory disorders is necessary for their proper use.
- d) Proper hygiene and diet are essential components of good health.
- e) Regular medical and dental checkups are important preventative measures in the maintenance of good health.

4. Societal Implications

- a) The prevention and early recognition of body disorders results in more productive individuals.
- b) A variety of occupations in the health sciences are available to students with interests related to the digestive or excretory system.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) reports of their activities;
- b) facility with and understanding of laboratory apparatus and techniques;
- c) ability to identify the parts of the digestive and excretory systems seen in a vertebrate dissection.

6. Safety Considerations

- a) The chemicals used in this unit, such as Benedict's solution, Fehling's solution, pepsin, and hydrochloric acid, should be treated with caution.
- b) Students should use protective eyewear and gloves during a dissection. All preserved specimens should be thoroughly washed in tap water prior to use. The laboratory should be well ventilated during the dissection.
- c) Students should be aware of possible allergic reactions to the chemicals used in this unit.
- d) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) investigate recent developments in modern dental techniques;
- b) investigate modern diagnostic techniques for gastrointestinal disorders (e.g., ultrasound, X rays that involve the use of radio-opaque dyes);
- c) visit a hospital laboratory;
- d) examine newspapers and magazines for articles that deal with the use or misuse of laxatives or antacids.

*See the subsection entitled "Student Activities" on page 5.

Core Unit 3

8. Some Teaching Suggestions

- a) In keeping with the theme of the course, teachers should emphasize that this unit begins the study of the input of nutrients to the human body.
- b) The recording of observations from experimental work in tabular form should be emphasized in this unit.
- c) The relationship between the structure of an organ and its function should be emphasized.
- d) Since this is an applied biology course focusing on humans, the vertebrate dissection should be related to human anatomy and function.
- e) Detergent may be used if bile is not available to demonstrate emulsification. The effect of detergent can be related to everyday examples (e.g., washing hair, washing dishes).
- f) The large surface area of the intestine can be illustrated by relating it to the surface area of a piece of paper folded into a fan.
- g) Stressful situations in the home, at school, or at work, their possible effects on the digestive system, and ways of dealing with this stress should be discussed.
- h) A pharmacist can be invited to discuss the variety of over-the-counter drugs that are available.

The Communication Network – Sensory Organs

Time: 15 hours

This unit focuses on the variety of human sensory mechanisms that monitor, interpret, and process environmental stimuli. The individual's sensory responses can be demonstrated through a variety of simple activities that illustrate the uniqueness of every person, particularly in terms of the interpretation of stimuli.

This unit may be divided into topics such as the following:

- ▶ The eye
- ▶ The ear
- ▶ Chemoreceptors
- ▶ Touch
- ▶ The central nervous system

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a curiosity in investigating the characteristics of their eyes, for example, visual field, near- or far-sightedness, and visual acuity (2a);
- b) an understanding of the underlying causes of hearing and visual disabilities and an image of people who have such disabilities as individuals capable of leading productive lives (4a);
- c) an appreciation for the use of technology (e.g., contact lenses, hearing aids, and laser surgery) in the treatment of sensory malfunctions (4a);
- d) a respect for animals used in assisting the disabled to overcome physical disabilities (e.g., seeing-eye dogs);
- e) a co-operative, understanding attitude in assisting and encouraging individuals with sensory disabilities;

- f) an appreciation for the need for the protection of the sensory receptors against environmental overstimulation (3e, 4c);
- g) a respect for the right of an individual to a quiet personal space (4d).

Skills. Students will have the opportunity to develop skill in:

- a) determining visual acuity, using the Snellen's eye chart (2a);
- b) accurately recording, organizing, and interpreting data related to personal characteristics, for example, vision, taste, touch, and reaction time (2a, 2d-2g);
- c) drawing ray diagrams to illustrate the path of light rays through the eye for near and far vision (2b);
- d) observing and identifying the near point, blind spot, and use of a perimeter for the determination of visual field (2a);
- e) dissecting the eye of a cow or sheep (2b);
- f) mapping the tongue for the major areas of taste, such as sour, sweet, salt, and bitter (2e);
- g) locating several reflex areas in the body, for example, below the kneecap of a bent knee and inside the inner elbow (2g).

Knowledge. Students will be expected to:

- a) describe the parts of a control system (e.g., stimulus, receptor, conductor, interpreter, effector, response);
- b) locate in a dissection, and state the function of, the major parts of the eye and associated structures (2b);
- c) describe the position of the image in the eye in the case of near- and far-sightedness and explain how additional lenses can correct the disorder (2a);
- d) distinguish between the location and function of rods and cones in the retina (2a);
- e) explain how the use of different lenses, such as concave, convex, polarized, or coloured (red, blue, yellow), may affect vision (2b);
- f) explain the term *optical illusion* and give a specific example to illustrate it (2c);
- g) describe proper eye care and hygiene, including safety precautions and first-aid procedures in case of injuries (e.g., the use of eyewash stations in laboratories, the importance of using a proper reading light, proper sanitation for contact lenses, the use of commercial eye solutions, the importance of safety glasses in workshops);
- h) describe common disorders of the eye (e.g., conjunctivitis, crossed eyes, cataracts, astigmatism) and indicate their possible treatment (2a, 2h);
- i) define the term *decibel* and relate it to the range and sensitivity in human hearing, as well as to the potential hazards of loud sounds from earphones and instrument speakers (2d, 3e, 4d);
- j) describe the function of the major parts of the human ear, including the pinna, eardrum, hammer, anvil, stirrup, cochlea, semicircular canals, auditory nerve, and Eustachian tube (2d);

- k) explain the dual role of the ear for hearing and balance control (2d);
- l) describe the interdependence of taste and smell in sensory perception (2e);
- m) state the areas of the body that are most and least sensitive to touch, heat, and cold (2f, 2i);
- n) define the terms *reflex* and *reaction time* and describe how they are affected by fatigue, stress, and drugs such as alcohol (2g);
- o) recall that the function of the nervous system is to keep the life-support systems functioning together;
- p) identify the basic regions of the vertebrate brain and state their function in relation to sensory functioning.

2. Student Activities

Students are to:

- *a) (i) test visual acuity, using Snellen's eye chart; (ii) perform experiments to investigate eye characteristics (e.g., red-green colour-blindness, depth perception, peripheral vision, pupil responses, near- and far-sightedness); (iii) perform experiments to determine the near point of each eye and to observe changes in the eye during accommodation; (iv) locate the blind spot, using the cross-and-black-circle diagram (8a);
- *b) (i) perform a dissection of a sheep or cow eye to locate the parts of the eye and its associated structures; (ii) demonstrate, using a model, the path of light rays in the human eye (6a, 8b);
- *c) examine illustrations of optical illusions;
- d) (i) demonstrate sound-wave phenomena by striking a variety of tuning forks of varying frequency and observing their wave forms; (ii) test their ability to detect sounds of low and high frequency, using an audio generator; (iii) perform experiments to investigate the effects of visual cues and body orientation on balance; (iv) examine a model of the human ear (6b, 6d, 8b);
- *e) (i) map taste regions of the tongue and relate them to the sense of taste (6c); (ii) close off the nose and compare the taste of similar samples of an onion and an apple (6c);
- f) determine the density of touch receptors in different areas of the body, using two-point discrimination;
- *g) (i) determine the reaction time for both hands; (ii) locate reflex areas of the body by gently tapping the knee and inside elbow with a rubber hammer;
- h) complete a library research project on disorders of the eye and the ear and their possible treatments;
- i) investigate the ability of the hand to estimate temperatures.

*See the subsection entitled "Student Activities" on page 5.

3. Applications

- a) A knowledge of the structure and function of the eye is fundamental to the development of appropriate eyeglasses.
- b) The eye is a sensitive organ that must be protected from bright sunlight and flying objects.
- c) Proper first-aid treatment of an eye injury resulting from an accident in the home, in the laboratory, or at work must be administered immediately to minimize damage.
- d) The application of a knowledge of proper lighting conditions for working or reading will help reduce eyestrain.
- e) Stereo equipment, such as personal radios and amplifiers, should be maintained at low volumes to prevent hearing loss, particularly when used with headsets and earphones.
- f) Physically disabled individuals may have to make compensations in their sensory development (e.g., improved sense of sound for blind individuals).

4. Societal Implications

- a) Through the development of technical devices, people with visual and hearing disabilities can be helped to lead happier lives.
- b) A knowledge of and adherence to safety procedures can reduce the incidence of sensory injuries.
- c) Technological advances have increased the individual's opportunities of coming into contact with super-stimuli that can cause sensory impairment.
- d) A respect for an individual's personal space should be fostered, particularly regarding noise pollution.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) ability to demonstrate proper dissection techniques and to identify the specific structures observed during the dissection;
- b) ability to organize a personal visual chart;
- c) formal laboratory reports.

6. Safety Considerations

- a) Students should use protective eyewear and gloves during dissections. All preserved specimens should be thoroughly washed in tap water prior to use. The laboratory should be well ventilated during the dissection.
- b) When simulating a state of temporary blindness, partners must remain in close proximity and warn the "blinded" student when he/she is approaching hazardous obstacles.

- c) Students should be surveyed for food allergies before they perform taste tests, and they should handle all test materials and solutions in a hygienic manner.
- d) Equilibrium experiments involving the rapid spinning of the body require a large space free of desks to ensure that students will not collide with anything should they lose their balance. Students should remove their eyeglasses and should work with partners to prevent falls. Gym mats could be used to help prevent injuries.
- e) Students wearing contact lenses should be aware of potential problems from the fumes from preservatives.
- f) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) perform light-ray experiments to investigate how a variety of lenses are used to correct near- and far-sightedness;
- b) investigate a variety of eyeglasses with different lenses to determine their effect on vision. Examples could include polarized lenses, smoked glass, welder's eyewear, and lenses of different colours (rose, blue, grey, yellow);
- c) investigate the phenomena of positive and negative after-images that result from looking at an object intently for a period of time;
- d) examine the variety of commercially available contact lenses, such as hard, soft, and porous types, and discuss the care and safety aspects of these lenses;
- e) use an astigmatism chart to determine the presence or absence of this disorder.

8. Some Teaching Suggestions

- a) Students should develop an awareness of their own visual capacities by doing a variety of experiments designed to develop a personal visual chart.
- b) Models can be used to demonstrate the structure and function of the eye and the ear.
- c) Guest speakers who have experienced sensory disability may assist students in becoming more aware of difficulties associated with these disabilities.
- d) It should be stressed that people with sight and hearing problems are able to adapt to their disabilities and can be productive individuals with adequate support and appropriate modifications in the community.

Core Unit 4

The Respiratory and Cardiovascular Systems

Time: 14 hours

The human body may survive for many days without food and for a few days without water, but death ensues very quickly without oxygen and an efficient transport system. This unit deals with the respiratory and cardiovascular systems. The influences of lifestyle on these systems is emphasized so that students may make decisions that can lead to a healthier life.

This unit may be divided into topics such as the following:

- ▶ The respiratory system
- ▶ The cardiovascular system
- ▶ Breathing
- ▶ Chemical respiration

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a curiosity in investigating how their cardiovascular system functions (2a-2d);
- b) a commitment to maintaining healthy respiratory and cardiovascular systems (4b);
- c) a respect for a clean-air environment for non-smokers;
- d) a commitment to assist individuals who are under respiratory or cardiovascular stress;
- e) critical-mindedness in using scientific knowledge when examining their lifestyle for strengths and weaknesses.

Skills. Students will have the opportunity to develop skill in:

- a) manipulating a stethoscope and using it to listen to breathing sounds (2a);
- b) measuring factors such as respiration values, blood pressure, and heart rates (2b-2d);
- c) recording and tabulating data on respiration values, heart rates, and blood pressure (2b-2d);
- d) calculating total lung capacity, expiratory reserve volume, and vital capacity (2b);
- e) interpreting data on the effect of mild exercise on the respiration rate (2b, 2c);
- f) following procedures during the dissection of a sheep or beef heart (2e);
- g) making and testing hypotheses to account for observed differences in respiratory and cardiovascular profiles within the class (2a-2d).

Knowledge. Students will be expected to:

- a) identify the components of air, including possible pollutants, and indicate the effect of changes in the levels of oxygen and carbon dioxide on the respiratory system;
- b) describe the function and location of structures involved in breathing, for example, the nose, trachea, bronchi, and alveolus (2a, 8f);
- c) differentiate between the composition of inhaled and exhaled air (2a);
- d) state the characteristics of a healthy respiratory system (2a, 2b);
- e) explain how smoking directly affects the respiratory and cardiovascular systems and may have implications for other systems as well (2g);
- f) explain the role of air-pressure changes within the chest cavity in controlling the mechanical process of breathing (8b);
- g) recall that cellular respiration involves the exchange of carbon dioxide and oxygen among cells as well as chemical reactions within cells;
- h) be able to list the main parts and function of the human heart (2e);
- i) describe the route taken by the blood in its circulation through the heart and the reason for this route (2e);
- j) identify the components of blood and state the function of each component (2f);
- k) compare and contrast the respiratory systems and circulatory systems of healthy and diseased individuals, working from X rays or photographs (2g);
- l) name at least two first-aid techniques used in cases of emergencies involving the respiratory or cardiovascular systems and describe how each functions (8d);
- m) describe the process of gas exchange in the blood.

2. Student Activities

Students are to:

- *a) use a stethoscope to listen to breathing sounds made by the lungs and trachea while resting and following vigorous activity (6b);
- *b) determine respiration values (tidal volume, expiratory reserve volume, inspiratory reserve volume, vital capacity), using a spirometer, for a standing, seated, and prone person and propose hypotheses to account for observed differences among their classmates (6b, 8c);
- c) try to listen to the sounds made by the heart or blood at several points in the body, such as the pulse points on the neck and the inside of the elbow and the wrist, and compare the heart rate and sounds before and after mild physical activity (6b);
- d) measure the blood pressure, using a sphygmomanometer before and after mild physical activity and before and after drinking coffee or cola, and then time the return to normal blood pressure (6b);
- *e) perform a sheep- or beef-heart dissection and trace the flow of blood through the heart, noting the location and construction of the chambers and valves of the heart (6b, 8f);
- f) examine a commercially prepared blood-smear slide for various types of blood cells;
- g) examine a variety of X rays or photographs of healthy and diseased lungs.

3. Applications

- a) Exercise, diet, and lifestyle have a profound effect on both the respiratory and cardiovascular systems.
- b) Qualified instructors teach courses on first-aid procedures for the cardiovascular and respiratory systems.
- c) Blood pressure varies widely with activity and is one of the many indicators of an individual's present state of health.
- d) Masks are necessary for safety within certain work environments (e.g., where insulation is being installed).

4. Societal Implications

- a) A variety of careers in the health sciences are available to students with interests in the respiratory or cardiovascular system.
- b) Smoking, air pollution, chemicals, and poor diet can cause deterioration of the respiratory or cardiovascular system.

- c) Individuals may find that first-aid and lifesaving techniques have immediate applications during their lives.
- d) The increased incidence of respiratory diseases, such as allergies and asthma, can be attributed to environmental pollution of air.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) ability to interpret data from laboratory work;
- b) records of laboratory work;
- c) ability to identify the parts of the heart in a sheep- or beef-heart dissection.

6. Safety Considerations

- a) Beef or sheep hearts should be washed thoroughly in tap water before dissection. Students should use protective eyewear and gloves during dissections. The laboratory should be well ventilated during the dissection.
- b) Students with medical problems related to the respiratory or cardiovascular system should be excused from any activities that would cause unacceptable stress.
- c) Equipment such as stethoscopes and spirometers should be sterilized before students use them.
- d) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) investigate and report on statistics on heart or lung diseases involving smoking, diets, allergies, and stress;
- b) prepare a dried pig lung;
- c) prepare a report on artificial hearts and organ transplants;
- d) investigate the effect of carbon dioxide concentration on breathing rates.

*See the subsection entitled "Student Activities" on page 5.

8. Some Teaching Suggestions

- a) Students can use a stethoscope to examine the sounds made by each of the parts of the respiratory system.
- b) A model of the chest cavity made from a bell jar and balloons can be used to illustrate the breathing mechanisms.
- c) Students can prepare a self-profile in tabular form of various aspects of the respiratory and cardiovascular systems. They can then compare their results with those of classmates and take class averages.
- d) First-aid techniques should be demonstrated by individuals trained to teach such procedures.
- e) A member of the local police department can be invited to the class to demonstrate the function of a blood-alcohol measuring machine.
- f) A pig pluck can be used to demonstrate the interrelationships between the respiratory and cardiovascular systems.
- g) Some sheep hearts and beef hearts have fat deposits on the heart and arteries. A discussion and illustrations of the effects of diet on the heart and arteries should accompany the dissection activity. Teachers should be aware of the controversial nature of theories regarding connections between diet and heart disease.
- h) Students may have already studied certain aspects of this unit as part of the health education program. It is highly recommended that teachers of this course confer with those teaching health education prior to teaching this unit in order to clarify what each course will accomplish, to reinforce certain concepts, and to reduce or eliminate overlap in content.

Core Unit 5

Genetics and Reproduction

Time: 14 hours

Students are regularly confronted with the issues surrounding sexuality, fertilization prevention, sexually transmitted diseases, and family planning. The purpose of this unit is to provide students with up-to-date scientifically determined information and explanations related to these issues. Many recent discoveries in the field of molecular genetics are particularly relevant in this regard.

This unit may be divided into topics such as the following:

- ▶ DNA and chromosome structure
- ▶ Body-cell and sex-cell formation
- ▶ Mendelian genetics
- ▶ The male reproductive system
- ▶ The female reproductive system
- ▶ The menstrual cycle, pregnancy, and birth
- ▶ Sexually transmitted diseases
- ▶ Fertilization prevention

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation for the quantity of information coded within the DNA molecule;
- b) an appreciation of the diversity of human characteristics and the role of genes in behavioural and personality traits (2d);
- c) a concern for the proliferation of mutagenic agents (3b);
- d) an appreciation of the fact that the union of two small sex cells produces a unique and very complex individual;
- e) objectivity in considering modern medical advances and research into *in vitro* fertilization (3a, 4c, 4e, 8a).

Skills. Students will have the opportunity to develop skill in:

- a) observing sperm and egg cells under the microscope (2a);
- b) using Punnett squares to carry out a pedigree analysis (2e);
- c) predicting the genotypes and phenotypes of offspring, given the genotypes or phenotypes of the parents (2e);
- d) observing genetically determined human characteristics (2d);
- e) recording and organizing data from the human-characteristics laboratory activity in tabular form (2d).

Knowledge. Students will be expected to:

- a) state that DNA is the basic hereditary chemical of life and that it acts by directing the assembly of amino acids and protein in the cell;
- b) explain the meaning of the following terms: gene, chromosome, body cell, sex cell (sperm and egg), phenotype, genotype, homozygous, heterozygous, mutation, mutagenic agent, zygote, embryo, fetus;
- c) state that the genetic code is the basis of inheritance;
- d) demonstrate examples of inheritance by drawing Punnett squares, using specific human characteristics (2e);
- e) explain the role of chromosomes in sex determination, fraternal and identical twins, and genetic disorders (e.g., Down's syndrome, Turner's syndrome, hemophilia);
- f) describe the structure and function of the parts of the male and female reproductive systems;
- g) list the organs of origin and the functions of the following hormones: testosterone, follicle-stimulating hormone, luteinizing hormone, progesterone, estrogen;
- h) describe the type of information provided by technologies of fetal analysis, such as ultrasound or amniocentesis;
- i) explain how specific environmental agents, and even prescribed drugs, may affect a pregnant woman and her fetus (e.g., tobacco, alcohol, cannabis, thalidomide, antibiotics);
- j) outline the biological basis of sexually transmitted diseases, such as AIDS, gonorrhea, syphilis, and vaginitis (8a, 8c);
- k) describe several natural and artificial methods of fertilization prevention and explain how each functions (8a, 8c).

2. Student Activities

Students are to:

- *a) examine prepared slides of human or rat testes to determine the size, shape, and numbers of sperm and prepared slides of a human or rat ovary to identify the follicles and oocytes;
- b) observe a dissection of a preserved pregnant vertebrate (6a);
- c) observe the laws of probability by flipping a coin many times and relating the results to a genetic cross;

- *d) observe and tabulate human traits that are genetically determined (e.g., blood type, Rh factor, hairline, freckles, finger hair, ear lobes and rim, colour blindness, ability to roll the tongue);
- *e) draw and use Punnett squares to explain patterns of single-gene inheritance of various human characteristics;
- f) draw a pedigree of a family, tracing the inheritance of easily determined phenotypes (e.g., the ability to roll the tongue);
- g) examine photographs of a human fetus at various stages of development.

3. Applications

- a) New advances in genetic engineering may result in the production of drugs to control human disease.
- b) Agents in the environment, such as alcohol, tobacco, and medical and other drugs, may cause mutations that result in genetic disorders.
- c) Genetic counselling, which is available to prospective parents, may improve the prospects of producing healthy offspring.

4. Societal Implications

- a) Human population is increasing in some parts of the world to the point where adequate food supplies are not locally available.
- b) Low birth rates can change the age distribution in a population.
- c) Boundaries may have to be set to limit present and future experiments in genetics.
- d) The responsibility for caring for individuals with genetic disorders is shared by the community as a whole.
- e) Screening programs are available for the detection of genetically determined disorders.
- f) Drug companies have to be made more accountable and responsible in their research in order to avoid mistakes (e.g., thalidomide).

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) facility in observing sperm and egg cells with the microscope;
- b) observations and records of human characteristics;
- c) ability to use Punnett squares to do an analysis of the inheritance of human characteristics.

6. Safety Considerations

- a) Students should wear gloves when handling preserved specimens.
- b) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) use a microscope to observe the eggs and sperm of snails for early stages of cleavage;
- b) prepare and examine slides of frog testes for sperm and frog ovaries for oocytes;
- c) perform test crosses, using fruit flies;
- d) obtain a photograph of a cell nucleus during mitosis and do a karyotype analysis;
- e) construct a model of a DNA molecule;
- f) dissect fresh smelt minnows or other small fish at spawning time to acquire sperm and eggs and attempt to observe fertilization taking place on a microscope slide;
- g) review and present for discussion data on common physical conditions, such as heart disease, diabetes, or cancer, that are caused by many factors;
- h) conduct a library research project on a topic such as the experiments of Watson and Crick, birthing techniques, birth defects, mutagenic agents, the role of Canadian scientists in genetic research, or the after-effects of a drug mistake (e.g., thalidomide) on the lives of those affected.

8. Some Teaching Suggestions

- a) This unit should focus on the biological principles and concepts necessary for an understanding of genetics and reproduction. The nature of this unit is such that many sensitive issues may be raised during class discussions. Teachers should treat these issues with care. Appropriate strategies for dealing with sensitive issues are outlined in subsection 10.2 of Part 1 of this science guideline. It is also most important that teachers of health and family studies be involved in the planning of this unit in order to present students with a balanced view of the scientific, social, and health considerations inherent in the study of human reproduction and genetics.
- b) Many excellent films are available on topics related to genetics and reproduction.
- c) Guest speakers from outside agencies, such as health units and nursing schools, should be encouraged to visit the class.
- d) There are many genetics centres in Ontario that have resource materials available for the use of teachers.

Core Unit 6

Waste Management

Time: 14 hours

A study of human biology is not complete without a consideration of the impact of humans on their environment. This impact results from the use of natural resources for food and manufactured materials and the subsequent release of waste into the environment. Waste in the environment may result in serious health and ecological problems. The management of the waste that results from human activities is important to prevent these problems. Students should appreciate the need to limit waste products and the need to develop strategies to control the waste that is produced.

This unit may be divided into topics such as the following:

- ▶ Suspended matter in water
- ▶ Chemical pollution
- ▶ Water purification
- ▶ Air pollution
- ▶ Garbage
- ▶ Waste treatment

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) objectivity in interpreting the results of the qualitative analysis of water and air samples (2b);
- b) a concern about safety when handling water samples of unknown purity (2a, 2b);
- c) an appreciation of the need to solve the acid-rain problem (2d, 2e, 2g);
- d) objectivity in evaluating responsibility for environmental pollution;

- e) a commitment to reducing the quantity of garbage generated at home (2h);
- f) a curiosity in evaluating the waste-management controls in the community;
- g) an appreciation that human and industrial waste can cause ill health (2i);
- h) objectivity when evaluating mass-media coverage of a waste-management issue (2j).

Skills. Students will have the opportunity to develop skill in:

- a) manipulating light or stereo microscopes when observing biological indicators of pollution (2a);
- b) interpreting data to evaluate air and water quality (2a, 2b, 2f);
- c) developing a classification scheme for water and air pollutants;
- d) determining the degree of acidity in samples of rain or snow (2g);
- e) organizing the collection of data in experiments;
- f) calculating the percentage composition of home refuse, for example, the percentages of paper, styrofoam, plastic, metal, and glass (2h).

Knowledge. Students will be expected to:

- a) list types of organisms found in water of varying quality (2a);
- b) list techniques used to purify and sterilize water (2c);
- c) outline the significance of the results of water- and air-pollution tests;
- d) explain, using word equations, how sulphur combustion results in the production of acid rain (2d);
- e) state the effect of acid rain on selected living organisms and on some common materials (2e);
- f) define the term *micrometre* (μm) (2f);
- g) distinguish between the terms *non-biodegradable* and *biodegradable* (2h);
- h) explain the function of the major components of a sewage-treatment plant and a household septic system (2i).

2. Student Activities

Students are to:

- *a) use a microscope to observe suspended matter and organisms in water samples obtained from a variety of sources (6a, 6b, 8e);
- *b) analyse collected water samples or teacher-prepared simulations for the presence of oxygen and pollutants, for example, lead, phosphate, and nitrate (6a);
- c) perform experiments to demonstrate purification techniques (e.g., filtration, flocculation);

- d) perform an experiment to demonstrate the production of acid rain from the results of sulphur combustion (6c);
- e) perform experiments to demonstrate the corrosive qualities of mild acid on plants, metals, and carbonates (6d);
- f) collect particulate matter from the air on a vaseline-covered slide for at least twenty-four hours and attempt to identify and classify the particles by type, size, and possible source (6b);
- *g) use indicators to determine the acidity of rain (or snow);
- *h) calculate the percentage composition of garbage generated in the home or classroom for a week (6e, 8h);
- i) evaluate and report on the effectiveness of the waste-management technology used in the community to treat human waste and dispose of refuse (8g);
- j) conduct a case study to determine the best location for a proposed waste-disposal site.

3. Applications

- a) The segregation of home garbage into biodegradable, glass, metal, paper, and plastic components makes the recycling of wastes possible.
- b) A knowledge of pollution standards will enable students to identify pollution that could cause health problems.
- c) A reduction in acid rain would reduce costs to replace damaged materials and would reduce the trend towards the increasing acidification of lakes, which threatens the survival of many aquatic species.
- d) People can adopt a way of life that minimizes negative impacts on the ecosystem (e.g., through conservation practices, clean-up campaigns, recycling).

4. Societal Implications

- a) Improperly treated human excrement and other wastes, for example, nuclear, animal, and industrial wastes, reduce the water and air quality in many Ontario communities.
- b) Much progress in reducing effluents has occurred over the last decade, but society should strive for greater advances as technology becomes available.
- c) Air pollution as a by-product of human activity poses a serious threat to the forestry and tourist industries, human health, and the balance of the world ecosystem.
- d) Pollution-control measures have been developed to reduce or eliminate wastes generated by human activities.
- e) The overpackaging of products with non-biodegradable substances creates serious disposal problems for the community.

* See the subsection entitled "Student Activities" on page 5.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) analyses of the components of polluted water;
- b) calculations of the percentage composition of home garbage;
- c) ability to use the microscope and report accurately on what they have observed.

6. Safety Considerations

- a) Caution must be exercised in handling any water suspected of being polluted.
- b) After handling chemicals and pollutants and after using slides, students should wash their hands, all desk surfaces, and the slides.
- c) Sulphur should be heated in a fume hood.
- d) Care should be exercised in handling acids.
- e) Students should wear masks and rubber gloves when handling garbage generated in the home or classroom.
- f) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) apply the analytical techniques learned in class to a study of a stream or lake in the area;
- b) study the effect of an acid atmosphere on plant structure and growth;
- c) analyse the paper waste in the school and design and implement a program to recycle it;
- d) keep a record of pollution-control readings and acid-rain watches for a period of time and relate these to geographical and meteorological factors;
- e) study lake-acidity data and predict the impact that acid rain could have in the next decade and beyond;
- f) shred, de-ink, and make new paper from old newspapers.

8. Some Teaching Suggestions

- a) This unit should focus on the theme of waste management in the home and the community. Students should be constantly aware of this theme and should consider the real costs to the taxpayer.
- b) The topics chosen for this unit will to a large extent depend on the time of year, the geography of the region, and the local technologies used in waste management. The student activities are designed to allow for this flexibility.
- c) A visit to a local sewage-treatment plant or solid-waste disposal site should be considered.
- d) A nutrient-rich aquarium seeded with algae can be started, observed, and tested over a period of a few weeks.
- e) Since some of the commercially available invertebrate keys are too difficult for many students, a simple list and pictures of indicator organisms should be provided.
- f) The reduction of wastes should be related to the wise use of energy.
- g) Teachers should be careful not to imply that technology alone will solve all pollution problems. Cost factors and political decisions might also be discussed.
- h) Students can be encouraged to analyse the garbage generated in either a home or a classroom. They should be provided with rubber gloves and masks and should be cautioned not to handle food wastes.

Optional Unit 1

Home Gardening

Time: 12 hours

Home gardening can provide families with a way of meeting their dietary needs without having to rely solely on purchased food. A knowledge of soil conditions and plant requirements is fundamental to planning and maintaining a garden. The intent of this unit is to provide the student with a basic understanding of the fundamental principles of gardening and some experience in selecting and handling plant materials.

This unit may be divided into topics such as the following:

- ▶ Soil nutrients
- ▶ Properties of soil
- ▶ Soil organisms
- ▶ Planning a garden
- ▶ Organic gardening
- ▶ Chemical control

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a concern about the effect of chemically treated foods on human health (2i, 3b);
- b) an open-mindedness towards new agricultural technologies (2g);
- c) an appreciation of the fundamental role of plants in the production of food and oxygen;
- d) a questioning attitude towards the indiscriminate use of pesticides and herbicides (2i, 3b);
- e) a commitment to the safe handling, disposal, and storage of pesticides, herbicides, and fungicides (2i, 3d).

Skills. Students will have the opportunity to develop skill in:

- a) analysing the nutrient content and pH of soil samples (2a);
- b) calculating the percentage of water in soil samples (2b);
- c) manipulating a microscope when determining nematode density (2c);
- d) organizing information when planning a garden plot (2e);
- e) graphing data obtained from the onion-germination-suppression experiment (2f);
- f) following procedures for growing vegetables hydroponically or for propagating house plants (2g, 2h);
- g) recording data from the labels on pesticide, herbicide, and fungicide containers (2i).

Knowledge. Students will be expected to:

- a) state the role in plant growth of nitrogen, phosphorus, potassium, and pH (2a);
- b) explain the symptoms of some common nutrient-deficiency diseases in plants (2a);
- c) list and state the importance of some physical properties of soil (2b);
- d) describe the role played in soil formation by soil organisms such as fungi, nematodes, and earthworms (2c);
- e) state the factors that must be considered for the successful planting and harvesting of a garden (2d, 2e);
- f) compare and contrast techniques used in organic gardening with chemical-gardening practices (2f);
- g) discuss the advantages and disadvantages of hydroponic gardening (2g);
- h) list common propagation techniques used in growing house plants (2h);
- i) differentiate among pesticides, herbicides, and fungicides (2i).

2. Student Activities

Students are to:

- *a) analyse soil samples for the presence of nitrogen, phosphorus, and potassium and determine the pH of the samples (6a, 8b);
- *b) calculate the water-holding capacity of soil samples (6a, 8b);
- c) perform an experiment that will determine the population density of soil nematodes (6a);
- d) investigate the conditions that are required to grow some vegetables or herbs commonly found in a small garden;
- e) draw a plan for a garden that would include various plants, showing the location that would maximize the yield of each;
- f) perform an experiment that would test the hypothesis that onions contain a substance that suppresses the germination of other types of seeds (8f);

*See the subsection entitled "Student Activities" on page 5.

- g) grow a vegetable hydroponically (6d);
- *h) propagate plants by such means as cuttings, grafting, and the germinating of seeds (6c, 6d, 8g);
- *i) examine the information contained on the labels of a variety of garden pesticides, herbicides, and fungicides regarding use, safety in storage, disposal of empty containers, and toxicity (6b).

3. Applications

- a) Proper cultivation methods can maximize food production at home and reduce home food costs.
- b) Organic gardening techniques can help to reduce pesticide residues in food.
- c) Propagation techniques provide an inexpensive way of increasing the number of house or garden plants.
- d) The safe handling of pesticides and herbicides may prevent the health problems that arise from long-term exposure to toxins.
- e) The propagation and maintenance of plants and gardens may provide many enjoyable hours of leisure activity for some people.

4. Societal Implications

- a) There are many careers in plant-related fields, such as landscape gardener, farmer, greenhouse operator, and florist.
- b) The decrease in soil quality and the quantity of arable land could result in serious food-supply problems in the future.
- c) New technologies, such as the use of solar energy and hydroponics, could help to decrease food shortages.
- d) Plants can be used to increase the quality of life, particularly in urban centres.
- e) The indiscriminate use of non-biodegradable pesticides and herbicides is a health and environmental threat.
- f) The development of a home garden is one way in which a family may lower its food costs, as well as come to appreciate the hard work involved in farming.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) calculations of the water-holding capacities of soils;
- b) laboratory reports;
- c) ability to care for experimental plants.

6. Safety Considerations

- a) Students should wash their hands after working with soil samples.
- b) Sterile soil should be used wherever possible.
- c) Students should be surveyed for allergies before they handle plant materials.
- d) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) examine microscope slides of herbaceous and woody stems to study plant growth;
- b) visit or invite to the class a plant specialist, such as a florist, landscape architect, food-crop specialist, or consulting agronomist, to discuss careers related to the plant sciences;
- c) germinate the seeds of Ontario trees and arrange for their planting;
- d) germinate and plant flowers for the school's garden;
- e) calculate the amount of money that could be saved by growing and preserving garden plants;
- f) investigate maintenance techniques, such as pruning for winter protection;
- g) investigate companion gardening.

8. Some Teaching Suggestions

- a) Teachers who choose this unit should carefully consider the time of year when it is to be taught in order to maximize student activities.
- b) Soil samples obtained from the home or farm can be analysed and compared to add more interest to soil testing.
- c) Students should be aware of the variety of jobs in the food-producing and food-processing industries.
- d) Many students show an increase in responsibility if they have their own plants to care for rather than a class set of plants. If the classroom facilities restrict space for plant-growth experiments, students may perform the experiments at home, bringing the plants to class on completion of the experiment.
- e) Plants that are used as decoration in the classroom can be used as a source of plant materials.
- f) The use of plant-growth fluorescent tubes over growing plants makes many of this unit's activities possible in winter.

Optional Unit 2

Skin

Time: 12 hours

The human skin has a wide variety of functions and, as the largest organ of the body, is subjected to a number of constantly changing environmental conditions. This unit examines the structure of skin and its roles as a sensing organ, as an organ of excretion, and in sustaining a homeostatic internal body condition. Skin care is vital to maintaining a healthy body. A variety of methods for keeping the skin and hair healthy are examined.

This unit may be divided into topics such as the following:

- ▶ Skin structure and function
- ▶ Skin as a sense organ
- ▶ Skin and hair care
- ▶ The scarring and wrinkling of skin
- ▶ Skin and hair disorders
- ▶ Skin allergies
- ▶ The effects of radiation

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a questioning attitude towards the variety of skin- and hair-care products described in the media (3a);
- b) a curiosity in discovering that there are both similarities and differences among the skin structures and patterns of various individuals (2a, 2b, 2d);
- c) an empathy for individuals who have skin disorders and an awareness of some of the causes.

Skills. Students will have the opportunity to develop skill in:

- a) recording and preparing data on skin (2a, 2c, 2d);
- b) using magnifiers or binocular microscopes to examine skin surfaces (2a);
- c) classifying and locating the skin nerve sensors, for example, touch, pain, heat, and cold (2c);
- d) designing an experiment dealing with sunscreens, hair care, or cosmetics (2f);
- e) interpreting the results obtained by mapping sweat-pore locations (2d);
- f) observing and classifying fingerprints from several individuals (2b).

Knowledge. Students will be expected to:

- a) describe the structure of skin (2a, 2c, 2d);
- b) describe typical fingerprint patterns (2b);
- c) state the functions of skin;
- d) outline the proper procedures for maintaining healthy skin and hair;
- e) state the characteristics, overall chemical composition, and proper use of hair- and skin-care products (2f, 2g);
- f) state the causes and effects of scarring and wrinkling;
- g) explain how to take care of common skin disorders;
- h) outline the effects of solar radiation on skin and hair;
- i) describe the characteristics of burns, allergies, and acne;
- j) describe first-aid procedures for skin problems (e.g., burns, acne);
- k) describe the symptoms of skin cancer;
- l) state the need for sunscreens to protect against solar radiation (2f);
- m) know the active ingredients and rating scales of sunscreen products (2f).

2. Student Activities

Students are to:

- *a) use a magnifying glass or binocular microscope to examine the surface structure of the skin, including the structure of scars, fingernails, cuticles, hair roots, freckles, and moles, and compare the surface of the palm to the back of the hand in relation to ridges and furrows, patterns, skin attachment, sweat-gland locations, thickness, hair presence, and structure;
- *b) use an ink pad to prepare fingerprints of each finger, classify fingerprints under one of the ten basic patterns, and compare the pattern of each print to that of other fingers on the same individual and to those of a laboratory partner;
- *c) prepare a skin-pattern map for nerve sensors (touch, pain, heat, cold) for the forearm and the calf of the leg;

*See the subsection entitled "Student Activities" on page 5.

- *d) prepare a map of sweat pores on different skin surfaces, using starch and iodine as an indicator (6a);
- e) compare the effect of immersing a finger of each hand in water at different temperatures and subsequently placing the fingers in water at the same temperature;
- *f) design, conduct, and report on an experiment, or do a library research project, on one of the following: (i) the protective nature of sunscreens, tanning oils, and instant tanning products; (ii) the effect of bleaches, rinses, dyes, hair-perming solutions, and hair removers on hair; (iii) the effect of various types of hair shampoos and conditioners on hair maintenance; (iv) the effect of a wide variety of cosmetics on skin health (6b, 8a);
- *g) compare the pore openings on different palms following vigorous activity, when one palm has been treated with an antiperspirant.

3. Applications

- a) A critical examination of the advertising statements in the media should allow students to select appropriate personal skin- and hair-care products.
- b) Suntan oils and sunscreens contain ingredients that protect the skin from harmful radiation to varying degrees.
- c) The comparison of fingerprint patterns may be used for purposes of identification.

4. Societal Implications

- a) Skin cancer may be a direct result of solar radiation. By understanding the nature and sensitivity of their own skin to such radiation, as well as the means of protecting it, students may reduce the incidence of skin cancer or severe burns.
- b) The early diagnosis of skin problems will allow for treatment and thus may prevent infection, loss of work time, or additional costs for hospital care.
- c) A wide variety of careers related to skin and hair care (e.g., cosmetologist, dermatologist) are available to students.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) laboratory reports;
- b) observations and classifications of fingerprints;
- c) preparation of skin-pattern maps for nerve sensors.

6. Safety Considerations

- a) A dilute solution of iodine should be used, and washing facilities should be available, when students are counting and locating sweat pores.
- b) Students should be surveyed for any allergies to the products used in this unit prior to performing any of the specific tests.
- c) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) study the effects of a variety of rinses, dyes, shampoos, and conditioners on a small lock of hair;
- b) investigate the effect of a variety of soaps on the emulsifying of liquid fat (oil);
- c) prepare a report on the current first-aid practices for skin problems and burns that are accepted by the St. John Ambulance or the Red Cross.

8. Some Teaching Suggestions

- a) Teachers may wish to invite a professional hairdresser, cosmetician, or dermatologist into the class to discuss practical hair and skin care.
- b) The activities in this unit that require students to organize data on the structure of skin provide them with an excellent opportunity to use tables and charts.
- c) First-aid instruction should be demonstrated by individuals trained to teach first-aid procedures. Presentations about first aid for the skin can be made by students who have completed the appropriate courses.
- d) Students can conduct a drugstore survey of the wide variety of over-the-counter drugs and skin-care products.
- e) Hair-care products can be tested on a sample of cat fur.

Optional Unit 3

Bones and Muscles – Body Support

Time: 12 hours

The skeleton provides the framework for the body. The protection of vital organs and the production of blood cells are also important roles of the skeletal system. Muscles are attached to the skeleton. In order to initiate body movements, they undergo contraction to perform flexion actions and relaxation to perform extension actions.

The purpose of this unit is to explain and illustrate the inter-relationship between muscles and bones in performing their respective roles in the body support system. Since the bones and muscles are integral to flexible and controlled movements, it is essential that students realize the limitations of the skeletal and muscular systems and understand how a good diet and proper exercise can lead to the overall health of the body.

This unit may be divided into topics such as the following:

- ▶ Bones
- ▶ Cartilage
- ▶ Joints
- ▶ Muscles
- ▶ Tendons and ligaments
- ▶ Disorders

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation for the interrelationship between bones and muscles in their role of supporting body tissues (2c);
- b) a curiosity about the structure of bones and muscles (2a, 2c, 2f);

- c) an appreciation for the relationship between the structure of the skeletal system and its various functions (2c);
- d) a commitment to using appropriate attire and safety equipment to protect the bones and muscles (2j);
- e) an appreciation of the need for proper warm-up and cool-down activities before and after periods of strenuous exercise (2j).

Skills. Students will have the opportunity to develop skill in:

- a) observing fresh or preserved specimens of long bones and identifying their major structures (2a);
- b) interpreting the results of chemical tests to determine bone properties (2b);
- c) classifying a selection of bones of a vertebrate skeleton according to the categories flat, long, and irregular (2c);
- d) identifying the structures of the support systems and describing their functions (2c);
- e) labelling diagrams of a synovial joint, for example, the knee or the elbow (2d, 2e);
- f) observing X rays or photographs of the human skeleton, noting the relationship of structures and possible disorders (2h);
- g) measuring fatigue time in the investigation of muscle activity (2i);
- h) measuring reaction time as affected by exercise and muscle fatigue (2i);
- i) dissecting striated muscle and associated structures (2f).

Knowledge. Students will be expected to:

- a) state the basic functions of an internal skeletal framework;
- b) list the basic structures of, for example, a long bone, compact and spongy bone, bone marrow, and articular and epiphyseal cartilage and state a function of each (2a);
- c) describe the chemical composition of bone tissue and relate this to diet and to its support function (2b);
- d) compare cartilage and bone tissue with respect to composition, physical properties, and function in the body (2a, 2b);
- e) describe how the shape and structure of a bone corresponds to its location and function in the body (2c);
- f) describe several skeletal adaptations that allow vertebrates, both bipeds and quadrupeds, to perform specific activities, for example, flight in birds and the movement of a thoroughbred race-horse (2c);
- g) describe the structure and function of a synovial (hinge-like) joint, using the knee or the elbow as an example (2d);
- h) compare the location, structure, and function of tendons and ligaments (2e);
- i) identify the structures of the human arm and pectoral girdle to demonstrate the antagonistic pairing of the biceps and triceps (2e);
- j) explain antagonistic pairing as it relates to muscle operation (2e);

- k) describe the three types of muscles and their major properties, characteristics, and location;
- l) describe how body movement is related to the principle of levers (2e);
- m) explain the significance of exercise for muscle operation, for example, the distinction between isometric and isotonic exercises, and explain the term *muscle fatigue* and how to deal with it (2i);
- n) distinguish between the terms *hypertrophy* and *atrophy* as related to muscle tissue under a condition of stress (strenuous exercise) or of inactivity, such as the condition that results from being in a cast (2i);
- o) describe first-aid treatments that are used for various injuries of the skeletal system (2j).

2. Student Activities

Students are to:

- *a) examine a fresh specimen of a long bone, whole and in longitudinal cross section, identifying and stating the function of compact and spongy bone, marrow, and cartilage (6a, 8a);
- *b) examine the appearance and rigidity of a bone before and after it has been placed in a dilute solution of hydrochloric acid for several days (6b);
- *c) examine a variety of vertebrate skeletons, for example, those of a bird, mammal, and human, noting similarities and differences, adaptations for specific functions, and differences between sexes (8b);
- *d) use a fresh specimen or a model of a knee joint to illustrate general joint structures;
- e) demonstrate antagonistic pairing in the operation of the biceps and triceps by raising and lowering an object placed in the hand and label the structures on a diagram;
- *f) examine fresh stewing beef by teasing apart fibres and connective tissue, using dissecting needles;
- g) use a fresh turkey or chicken appendage to demonstrate tendon operation in the limb;
- *h) observe X rays or photographs of the human skeleton, noting the relationship of the various structures (including the major joint types) and possible disorders indicated by surgical treatments, such as the use of metal pins and staples and cartilage replacement;
- *i) investigate muscle fatigue and reaction time during a repeated activity, such as lifting an object by using an extended straight arm (8e);
- *j) complete a library research project on the types of bone and muscle injuries associated with sports (e.g., sprained ankles,

cramps, tennis elbow, torn ligaments, jogger's knee) and their possible first-aid treatments; *or* complete a library research project on and describe a common disorder of bones, muscles, or joints (e.g., osteoporosis, osteomyelitis, calcification, bursitis, sprains, dislocations, arthritis, gout, muscular dystrophy, poliomyelitis).

3. Applications

- a) The diet must include a source of appropriate minerals to ensure proper bone development and maintenance during the formative or growth years, as well as during the adult years to prevent bone-density loss.
- b) A person's overall body plan affects his/her body capabilities and may limit body movement in specific exercises. This concept may help students select sporting events in which they have a greater opportunity to excel.
- c) The selection of appropriate exercise programs to achieve specific goals such as endurance or strength, depending on the specific needs of the individual, is facilitated by an understanding of the body support system.
- d) Proper warm-up and cool-down exercises should reduce the frequency of injuries to muscles and associated support structures.
- e) Exercise and proper nutrition are major constituents in the maintenance of good health in body systems.
- f) The selection of appropriate personal apparel for an activity is made easier by a knowledge of the body's support system.
- g) A knowledge of proper first-aid treatment may reduce the severity of a body injury.

4. Societal Implications

- a) An emphasis on physical fitness, which results in good skeletal and cardiac muscle tone, produces a healthier and more productive population.
- b) Many careers involve the muscle and skeletal systems (e.g., chiropractor, fitness instructor, trainer of athletes).

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) experimental data and formal laboratory reports;
- b) ability to demonstrate proper dissecting techniques;
- c) library research into and description of the treatment of bone and muscle disorders.

*See the subsection entitled "Student Activities" on page 5.

6. Safety Considerations

- a) Students should use gloves and protective eyewear during a dissection. Specimens should be washed in tap water prior to use.
- b) Caution must be exercised in the handling of acid.
- c) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) investigate the mineral composition of bone, using dilute nitric acid to dissolve crushed bone tissue and subsequently performing appropriate chemical or flame tests;
- b) compare the structure of a skeleton and a bridge in terms of the support provided by girdles and arches;
- c) explain the significance of limb position in various classes of vertebrates, such as fish, amphibians, and mammals;
- d) investigate the significance and types of levers in the body;
- e) prepare and examine microscope slides of striated, smooth, and cardiac muscle tissue;
- f) investigate different types of exercise (e.g., isometric, isotonic, endurance, strength) and indicate the outcome of each.

8. Some Teaching Suggestions

- a) The memorization of bone nomenclature should be kept to a minimum.
- b) The interrelationships of muscles and bones and their organization to perform a particular function is an important concept and should be emphasized.
- c) Guest speakers, such as a representative from a sport clinic, a team physician, a physiotherapist, or a chiropractor, may add interest to the unit.
- d) Students should be encouraged to seek medical treatment when they experience an injury to the skeletal or muscle system.
- e) The importance of exercise in the development and maintenance of a healthy and fit body should be stressed, particularly in relation to the notion that a fit body usually is less prone to injuries that result from activity.
- f) An individual with first-aid training should be invited to demonstrate these skills.

Optional Unit 4

Mammal Dissection

Time: 6 hours

This unit is intended to complement the units in this course dealing with vertebrate systems. Through the integration of this unit with the others, the student dissections of a mammal, such as a white rat, will be more relevant to the course. During the dissection process students will have the opportunity to develop further their laboratory observation skills and to assimilate previous knowledge of each system studied in an attempt to interrelate them. The knowledge objectives will need to be modified if a mammal other than the rat is chosen for the dissection.

This unit may be divided into topics such as the following:

- ▶ External features and integuments
- ▶ The sensory system
- ▶ The digestive system
- ▶ The excretory system
- ▶ The respiratory system
- ▶ The circulatory and lymphatic systems
- ▶ The reproductive system

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a respect for the complex organization and interdependence of the organ systems in all living things (2a);
- b) a co-operative attitude when working with a laboratory partner during the dissection (2a);
- c) a questioning attitude towards anatomical study (2a);
- d) a curiosity in learning about the internal and external body mechanisms (2a).

Skills. Students will have the opportunity to develop skill in:

- a) manipulating dissecting instruments precisely and accurately (2a);
- b) maintaining dissecting instruments in good working order (2a);
- c) storing dissecting equipment and specimens in a clean and organized manner (2a);
- d) following laboratory instructions in proper sequence (2a);
- e) identifying specific structures and observing their orientation and relationship to associated structures;
- f) inferring the interdependence of systems from their organization in the body as a whole (2a);
- g) sketching and labelling diagrams of each system as observed during the dissection (2b);
- h) recording observations of each system in an organized and precise manner.

Knowledge. Students will be expected to:

- a) define basic anatomical terms used in locating body structures during dissection, such as the following: dorsal, ventral, medial, anterior (frontal), posterior (caudal), superior, inferior (2a);
- b) identify the major components of the external features, such as the following: hair, teats, lips, urogenital and anal openings, tail, claws, scrotum in male specimens (2a);
- c) (i) identify structures associated with the sensory system, such as the following: pinna, whiskers, external nostrils, eyes, upper and lower eyelids, nictitating membrane (2a); (ii) describe structural adaptations of sensory structures to assist in the receiving of stimuli, for example, a short flexible pinna supported at its base by cartilage to rotate in the direction of a sound and to funnel the sound waves towards the ear drum (2a);
- d) describe the pattern of hair distribution on the body and contrast the reptilelike scales of the skin on the tail to human skin (2a);
- e) compare the foot structure of the rat to that of other quadrupeds and to the hand and foot of the human, noting special human adaptations for flexibility and support, for example, an opposable thumb and foot arches (2a);
- f) identify the major teeth types and describe how structure, shape, and position on the jaw are related to their function in eating (2a);
- g) compare the shape, texture, and point of attachment of the rat's tongue to the corresponding features of the human tongue;
- h) identify the major structures in the head, neck, and thoracic region that are associated with digestion, breathing, and circulation, for example, salivary glands, larynx, epiglottis, trachea, thyroid glands, jugular veins, and carotid arteries (2a);

- i) identify and state the function of the capillary network and connective tissue (2a);
- j) describe the distribution of fat and the blood-vessel network associated with the mesentery that supports the small intestines (2a);
- k) identify the orientation of the muscle fibres in the thoracic and abdominal regions (2a);
- l) (i) compare the internal stomach structure of the rat to that of the human and outline the function of the rugae and mucus secretions (2a); (ii) describe the significance of the length of the digestive tract (2a); (iii) identify and describe the function of the major structures of the digestive system;
- m) identify the major structures of the excretory system and recall their close proximity to the reproductive structures (2a);
- n) (i) identify the major structures of the respiratory system; (ii) describe the structure of the trachea and its orientation to the esophagus during breathing and swallowing (2a);
- o) (i) identify the four chambers of the heart and the associated valves and blood vessels; (ii) relate heart-wall thickness to heart function (2a);
- p) identify the major reproductive structures of both sexes (2a);
- q) identify the major blood vessels in the rat, for example, aorta, carotid, vena cava, renal, hepatic, femoral, pulmonary, and jugular (2a);
- r) (i) identify the locations of the lymph glands (nodes) and spleen (2a); (ii) apply the principle of muscle operation to explain the movement of lymph through the body (2a).

2. Student Activities

Students are to:

- *a) perform a basic dissection of a white rat, locating the major structures of the systems that have been studied and noting the interrelationships of the various systems;
- *b) sketch and label simple diagrams to locate the structures of each system;
- c) prepare a colour-coded diagram that indicates each system as it is dissected.

3. Applications

- a) Basic anatomical knowledge should help students to understand medical explanations given by a health professional.
- b) Injury in one body location may lead to pain in another region. A knowledge of the interrelationship of body regions may help students understand body injuries.

* See the subsection entitled "Student Activities" on page 5.

4. Societal Implication

A knowledge of anatomy is essential for many careers (e.g., doctor, nurse, physiotherapist), as well as for an understanding of the workings of one's own body.

5. Evaluation of Student Achievement

At least 75 per cent of the term mark for this unit is to be based on students':

- a) co-operation with a laboratory partner when performing the dissection;
- b) laboratory reports and labelled diagrams at various stages of the dissection;
- c) practical laboratory tests, using class specimens.

6. Safety Considerations

- a) Students should use protective eyewear and disposable gloves during the dissection.
- b) Students should wash their hands thoroughly with soap before leaving the lab.
- c) Specimens should be rinsed in water prior to use.
- d) Appropriate ventilation should be provided during the dissection.
- e) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extension

Some students might do a comparative anatomical survey of other vertebrates, such as a leopard frog, snake, or bird.

8. Some Teaching Suggestions

- a) The following sequence of stages provides a logical progression for the dissection: external features and integuments; mouth region; ventral dissection through the thoracic trunk and abdomen to investigate the digestive, excretory, reproduction, circulatory, and respiratory systems; dorsal dissection of the spinal column, noting neural and blood-vessel association.
- b) Detailed terminology should be avoided. It is more important that students appreciate the overall scheme of the body; understand common disorders and their location, possible cause, and treatment; and understand the interrelationship between selected structures.
- c) Labelled sketches are helpful for reviewing dissected areas. Students should be encouraged to use these as opposed to copying printed technical drawings. These sketches should be accurate but need not be artistic.
- d) Students should constantly be reminded that the mammal being dissected is acting as a model on which analogies to the human body can be drawn.
- e) Comparisons to other mammals at various stages of dissection can be useful for noting physical adaptations and the uniqueness of species in performing different functions well (e.g., the teeth of the human, rat, beaver, sheep, and horse can be contrasted).
- f) Those systems not covered in detail in specific units may require greater explanation and discussion during dissection.
- g) A laboratory manual that uses simplified terminology and outlines an appropriate sequence for doing the dissection can be helpful to students.

Optional Unit 5

Humans and the Environment

Time: 12 hours

The purpose of this unit is to focus on the role and impact of humans on the environment.

This unit may be divided into topics such as the following:

- ▶ Matter, energy, and population growth
- ▶ North American food consumption
- ▶ Food and developing nations
- ▶ Homeostasis in the ecosystem
- ▶ Waste-disposal-site selection
- ▶ Recycling
- ▶ Global ecological issues
- ▶ Local environmental and ecological issues

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) critical-thinking skills in examining various sides of an ecological issue (2d);
- b) an appreciation of the fact that solutions to environmental problems involve contributions from many subject areas (e.g., science, economics, sociology, political science);
- c) a respect for the fragile ecological balance of components of the ecosystem;
- d) a questioning attitude towards the reporting of ecological events by the various media (2d, 3a);
- e) a commitment to reducing personal garbage and to making better use of our natural resources (2b);

- f) a concern for existing wildlife areas and a commitment to the preservation of ecologically unique areas (2g);
- g) critical-mindedness in extrapolating exponential curves and realizing that such curves are only projections and may have restricted use (2b).

Skills. Students will have the opportunity to develop skill in:

- a) graphing and interpreting exponential curves, using data from a geometric growth activity (2a);
- b) inferring future population and consumption trends by extrapolating from graphs (2a);
- c) predicting the possible effects of ecological changes on the environment (2e);
- d) locating information about and debating local environmental issues (2f, 2g);
- e) collecting statistics for a variety of ecological problems related to population, consumption, and production (2b, 2e);
- f) reporting the results of their research to the class, orally or in written form (2c, 2e);
- g) listening objectively to the views of other students.

Knowledge. Students will be expected to:

- a) outline the meaning of the following terms: ecology, homeostasis, ecosystem, niche, biotic, abiotic, carrying capacity, exponential, acid rain, recycle;
- b) identify local environmental issues (2c, 2f, 2g);
- c) recall that humans have the ability to improve the quality of their lives by improving the quality of their environment (2b, 2c);
- d) give reasons why the quantity of matter and available energy cannot keep pace with present population growth (2b);
- e) describe the growth rate of the global human population (2b);
- f) describe the waste produced by individuals and relate this to the pollution that affects the environment (2c);
- g) demonstrate how environmental abuse can upset the homeostasis of the ecosystem and threaten the quality of life (2e);
- h) describe the complexity of an environmental issue that involves a variety of interrelated factors (2f, 2g);
- i) describe how environmental standards are set and monitored by a variety of governmental agencies and relate this to concerned and informal pressure from voters and lobby groups and the limitations on the ability of governmental agencies to monitor thoroughly and effectively.

2. Student Activities

Students are to:

- *a) prepare and compare two graphs, the first on the results of doubling a penny each year for thirty-five years and the second on world-population statistics from the year 500 to the present (8a);
- b) (i) make a list of the variety and quantity of food they have consumed in a single day and, using world-population statistics, estimate the quantity of animals and plants that would be consumed in a single day if the entire world ate at this rate; (ii) estimate the quantities of water, iron and steel, petroleum, and food used by the average North American in a lifetime; compare this figure to the quantities of wastes discarded in a lifetime (e.g., the kilograms of garbage, cans, and automobiles); apply these statistics to any developing nation and draw conclusions about the effect on the environment if the developing nation chosen imitated the North American standard of living (8b); (iii) draw conclusions about the effect on the environment if North Americans reduced their standard of living to that of a typical developing nation (8b);
- c) (i) prepare a list of the industrial wastes produced from a number of local industries and (ii) discuss the various issues that revolve around the selection of an appropriate waste-disposal site, for example, the needs for the site, the transportation of wastes to the site, and the ecological problems involved in the site selection (8c);
- d) examine and discuss both sides of the seal-harvest controversy, including the economic and political aspects as well as the ecological impact on fisheries of an unchecked, growing seal population;
- *e) conduct a library research project on one of the following and project its effects on the environment to the year 2050: the greenhouse effect caused by an increase in carbon dioxide, a decrease in photosynthesis caused by the removal of northern and tropical forests, the pollution of the oceans, the effect of uncontrolled acid rain on the world's forests, a case study of a particular pollution incident such as a chemical spill (8g);
- f) examine both the economic and the ecological needs of the local area in relation to a local environmental issue (8e, 8f);
- *g) select a local area that they feel is environmentally sensitive or unique and prepare a report that would contribute to zoning the area as parkland or public open space after examining both the needs of industry and the need for preservation (8e, 8f).

3. Applications

- a) Localized air pollution can lead to a temporary greenhouse effect in major urban areas.
- b) Garbage, whether produced by individuals or by industry, is a problem that concerns every citizen. A reduction in unnecessary garbage will lower total clean-up costs.

4. Societal Implications

- a) North American lifestyles strain the world ecological balance and may result in shortages of many natural resources.
- b) Projections indicate that certain global problems will be a concern to everyone. Thus, the reduction or elimination of these problems will benefit everyone.
- c) Environmental issues always have many sides. By considering all sides of an issue, we can make rational and logical decisions.

5. Evaluation of Student Achievement

At least 40 per cent of the term mark for this unit is to be based on students':

- a) library research projects;
- b) preparation and interpretation of graphs of an activity that involves exponential growth.

6. Safety Considerations

No safety considerations are applicable to this unit.

7. Possible Extensions

Some students might:

- a) examine how science is attempting to cope with exponential demands for food by developing so-called miracle foods and rapid-growing crops;
- b) examine the role and effectiveness of a variety of environmentally concerned groups.

8. Some Teaching Suggestions

- a) Students should use appropriate scales on graphs if they are to compare the relationship between two exponential growth curves.
- b) The problems of giving developing nations opportunities to improve their standard of living are complex; the results of doing so would be very demanding on the biosphere. Teachers should be aware that discussions involving certain developing nations may be sensitive issues for some students.
- c) Simulations of local environmental issues should include a problem-solving-model approach that includes decision making on all sides of the issues.
- d) Homeostasis within the individual contributes to the survival of that individual and has been considered during the physiology units. Homeostasis within the ecosystem is also necessary for survival, and teachers can use examples in which interference by humans in a natural ecosystem has upset the balance.
- e) A presentation to a local municipal government can follow research on the rezoning of a local ecological site.
- f) If an environmental issue is discussed at a local municipal council meeting, students can go to the council meeting to analyse the debate.
- g) Relevant data for use and research are readily available from a wide variety of government publications as well as from library resource materials.

Optional Unit 6

Behaviour and the Central Nervous System

Time: 6 or 12 hours

This unit focuses on the relationship between the nervous system and behaviour. Although science has much to learn about human behaviour, students can acquire a basic knowledge of, and begin to understand, some aspects of it.

This unit may be divided into topics such as the following:

- ▶ Reflexes
- ▶ The co-ordinated responses of invertebrates
- ▶ The central nervous system
- ▶ Innate behaviour
- ▶ Learned behaviour
- ▶ Abnormal personalities
- ▶ The effect of drugs on the central nervous system and on behaviour

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation of the complexity of the nervous system;
- b) a respect for the care of live specimens (2a);
- c) a curiosity in examining behaviour patterns (2a, 2d);
- d) critical-mindedness in choosing and applying knowledge of good learning environments and study techniques (3c);
- e) an empathy for and understanding about individuals with abnormal personalities and learning disorders (3e, 4b, 4c);
- f) a concern for the avoidance of spinal-cord and brain injuries (3a, 4b).

Skills. Students will have the opportunity to develop skill in:

- a) observing various behaviours;
- b) handling live specimens appropriately (2a);
- c) classifying behaviour as either innate or learned (2a, 2b);
- d) inferring proper study habits (2e);
- e) inferring from observation the adaptive value of the co-ordinated responses of invertebrates (2a).

Knowledge. Students will be expected to:

- a) describe the structure and physiology of the neuron, a synapse, and the reflex arc (2b);
- b) identify the protective structure and mechanisms of the brain and spinal cord;
- c) outline the causes and effects of physical trauma to the brain and spinal cord;
- d) describe the effects of some disorders of the central nervous system (e.g., strokes, meningitis, cerebral palsy, spina bifida, multiple sclerosis);
- e) identify the basic structures and functions of the vertebrate brain (2c);
- f) state the basic human drives and outline their adaptive significance (2d);
- g) recall some instinctive vertebrate behaviours and state their adaptive significance (2d);
- h) identify some examples of effective learning techniques (2e);
- i) identify the possible causes, symptoms, and accepted treatment, where possible, of various personality disorders (e.g., phobias, obsessions, compulsions, kleptomania, psychopathy, drug abuse, Alzheimer's disease, senility, depression, schizophrenia, paranoia);
- j) identify the symptoms and possible treatment of various learning disorders;
- k) describe various types of medical and non-medical drugs and their effects;
- l) describe the relationship between normal individual behaviour and the influence of peers, crises, or a large group on the behaviour of an individual.

2. Student Activities

Students are to:

- *a) (i) observe co-ordinated responses to darkness and bright light in invertebrates, such as an earthworm; (ii) observe the response of an earthworm to ammonium hydroxide fumes (6a);
- *b) observe various reflexes, such as the following: (i) the constriction of the pupil when a dark-adapted eye is subjected to

bright light; (ii) the blinking of the eye in a startled response; (iii) the familiar knee-jerk reflex;

- c) dissect a preserved sheep brain or a dorsal cranial section of a vertebrate (6b);
- d) do a library research project to investigate examples of instinctive behaviour, such as communication in honey bees, bird migration, the mating behaviour of the stickleback, nest building in birds, or the spinning of the spider's web (8b);
- *e) participate in at least three of the following: (i) a conditioning experiment; (ii) an experiment to demonstrate how memory is related to habits; (iii) a nonsense-learning exercise; (iv) a learning-with-distractions exercise; (v) a trial-and-error exercise; (vi) a data-base exercise; (vii) an experiment to investigate three sensory routes to learning (aural, visual, tactile) (8d-8g);
- f) conduct a library research project on examples of and treatment for one of the following: a mental illness, a central-nervous-system injury, or a learning disorder.

3. Applications

- a) Brain and spinal-cord injuries can have a profound debilitating effect. An understanding of their causes and of ways of avoiding them is vital.
- b) The early recognition and treatment of any learning or behavioural disorder is beneficial to the individual affected.
- c) It is important to recognize that proper personal study techniques are a component of success.
- d) Success at school improves an individual's feelings of self-worth.
- e) Through a knowledge of mental illness, students may be more sympathetic to those with mental disorders and thus accept them as full members of society.

4. Societal Implications

- a) The early recognition and treatment of any disorder reduces loss of school and work time and health-care costs.
- b) Individuals with brain or spinal-cord disorders, as well as the mentally ill, can be valuable, contributing members of our community.
- c) A better understanding of mental illness and physical disorders could result in acceptance of group homes in a community.
- d) Many careers in the health and educational fields are available to individuals who have an interest in learning about disabilities, brain and spinal-cord injuries, and mental illness.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) observations of behaviours;
- b) laboratory reports.

6. Safety Considerations

- a) Students should wash their hands after working with live and preserved specimens.
- b) Students should use gloves and protective eyewear during dissections.
- c) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) research, or perform experiments to determine, the co-ordinated responses of other invertebrates (e.g., the avoidance reactions of *Planaria* to light, the attraction of *Drosophila* or *Euglena* to light);
- b) perform experiments to determine tropisms in plants;
- c) do a library research project on the various reflexes and their adaptive value in the newborn;
- d) assist a learning-resources teacher;
- e) do a library research project on the influences of stress on physiology and behaviour;
- f) observe films or videotapes demonstrating the behaviour of individuals in large groups.

8. Some Teaching Suggestions

- a) Teachers should be very sensitive to those students in the class who may have had personal contact with an individual with a personality disorder.
- b) Many excellent films on animal behaviour are available.
- c) A representative of the Mental Health Association or the local health unit, a psychiatrist or psychologist, or a representative from Alcoholics Anonymous (Al Anon or Alateen) or the Addiction Research Foundation can be invited to speak to the class.

- d) Conditioning can be demonstrated in the following manner. Standing at the back of the room, out of the students' sight, the teacher asks students to tally the number of times that he/she utters a word while providing an auditory cue (e.g., tapping the desk with a ruler) at the same time that the word is spoken. This is continued until the desk is finally tapped without the accompanying word. Many students will tally that tap too, as if a word had been spoken.
- e) The relationship of memory and habit can be demonstrated in the following ways. Students are asked to name all of the streets, or the names of all of the stores, that they pass on their way to school; a blindfolded student can be asked to explain to another student how to tie a bow.
- f) Nonsense learning can be demonstrated by providing students with the following lists:

<i>Column A</i>	<i>Column B</i>
shall	I
see	think
poem	that
as	I
tree	shall
think	never
I	see
never	a
a	poem
lovely	lovely
a	as
I	a
that	tree

Students can be asked to memorize each of the two columns in a given amount of time. The results can then be compared.

- g) Learning with distraction can be demonstrated in the following manner. Students are asked to memorize some material, such as random numbers, in a quiet environment. The exercise can be timed. Students are then asked to memorize a comparable amount of material (different but a similar type of random numbers), only this time with some distractions. The results of the two exercises can then be compared.
- h) Teachers should demonstrate that large volumes of information may be organized in such forms as tables, graphs, and charts.
- i) It is not the intent of this course to have students memorize anatomical names and functions of parts of organisms in great detail. Only the major part of the brain should be identified if a dissection is done.

Optional Unit 7

Locally Designed Unit

Time: 6 or 12 hours

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of biology not described in this guideline or to incorporate additional objectives that will expand a previous part or parts of the course. The time chosen for this unit should be such that, when it is combined with the other optional units, a total of twenty-four hours is allocated. The following are examples of new areas or topics that might be considered:

- ▶ The endocrine system
- ▶ Microbiology
- ▶ Careers in the life sciences
- ▶ Ecological relationships
- ▶ Humans and invertebrates
- ▶ The diversity of organisms

This unit can provide an excellent opportunity for students to engage in independent or small-group study on a topic in biology that is of particular interest to them and that is approved, monitored, and evaluated by the teacher. Care should be taken not to allow the work to overlap with subject matter in other science courses that students are likely to take. The unit could be started after students have had some experiences in the laboratory and are well aware of accident prevention. If a series of short topics is considered, the topics may be fitted into the course schedule from time to time throughout the semester or year.

A locally designed unit is to incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, societal implications, and safety considerations. An outline of the unit is to be included in the course of study and kept on file in the school so that it is available to interested students and parents.

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Applied Chemistry, Grade 11, General Level (SCA3G)

Core Units

Qualitative Analysis
The Structure of Matter
Properties of Substances
Chemicals in Action
Acids and Bases

(78 hours)

Optional Units

The World of Carbon Chemistry
The Chemistry of Consumer
Products
Metallurgy
Nuclear Chemistry
Locally Designed Unit

(32 hours)

Core Unit 1

Qualitative Analysis

Time: 16 hours

Qualitative analysis deals with the identification of the different substances present in a sample. The purpose of this unit is to give students the opportunity to experience the excitement of searching for “unknowns” in such samples through activities in the laboratory. There is an abundance of applications of qualitative analysis in society, such as product control in industry, pollutant identification in the environment, and water testing in the home. By performing tests for particular substances, students learn the relevance of qualitative analysis, an important branch of analytical chemistry, and its impact on society.

This unit may be divided into topics such as the following:

- ▶ Analytical chemistry
- ▶ Tests for cations
- ▶ Tests for anions
- ▶ Applications of qualitative analysis

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation of the usefulness of qualitative analysis for the quality control of foods and manufactured goods (3a, 4a);
- b) an enthusiasm for investigative work;
- c) confidence in their ability to investigate a problem to its conclusion, support their results with evidence, and communicate their findings;
- d) an objective approach in challenging the evidence and inferences of investigative work;
- e) a concern for the safety of others when working in a group.

Skills. Students will have the opportunity to develop skill in:

- a) manipulating laboratory apparatus and equipment properly and safely;
- b) summarizing their observations in tabular and chart forms (2a, 2b);
- c) following written and oral instructions to determine the presence or absence of a substance in a sample;
- d) observing and comparing the properties of various substances that may be used to separate the components of a sample (2a, 2b);
- e) using an investigative approach to solve problems;
- f) using solubility charts to assist in the actual separation of unknown ions (2a, 2b, 2f);
- g) using simple flow charts to design an experiment to identify unknown ions (2a, 2e, 2f).

Knowledge. Students will be expected to:

- a) describe the organizational features of a flow chart or table that outlines a separation scheme for cations or anions (2a, 2b, 2e, 2f);
- b) recognize positive test results for several common cations and anions (2a, 2b, 2e, 2f);
- c) interpret solubility tables to identify unknown ions in a given sample (2e, 2f);
- d) list, with the aid of solubility tables, some substances that will readily precipitate;
- e) distinguish between observation and inference;
- f) state examples of the usefulness of qualitative analysis in society (3b-3e, 4b-4e).

2. Student Activities

Students are to:

- *a) test some substances for a variety of cations, using a separation scheme and including appropriate flame tests (5a, 6b, 6d, 6e, 8f);
- *b) perform simple anion tests, such as those for sulphates, nitrates, carbonates, and halides (5a, 6b, 8f);
- *c) analyse two household chemicals, such as baking soda, table salt, bleach, detergents, and fertilizers, for selected cations and anions (5a, 6b, 6d, 8c);
- *d) test some consumer products for the presence of vitamin C or reducing sugars (5a, 6e, 8c);
- e) solve for an unknown in a practical situation such as a simulated forensic-science setting, for example, match soil samples containing metal-salt contaminants (8c, 8e);
- f) analyse a sample of a substance for a suspected contaminant, such as iodide in table salt (8c, 8d).

* See the subsection entitled “Student Activities” on page 5.

3. Applications

- a) Qualitative analysis is important in the quality control of food, drugs, and cosmetics.
- b) Qualitative analysis, a branch of analytical chemistry, is used in the identification of toxic substances (e.g., in forensic science).
- c) Blood and urine testing can indicate the presence of drugs in the body.
- d) Environmental chemistry relies on qualitative tests of soil and water to identify pollutants or contaminants.
- e) Breathalyzer tests are an important use of qualitative and quantitative analysis in law enforcement.

4. Societal Implications

- a) Without quality-control standards that are set and monitored by government and industry, society could be subjected to products with widely varying degrees of purity.
- b) Forensic science uses qualitative and quantitative tests in gathering evidence for criminal investigations, thereby assisting the cause of justice.
- c) The medical profession relies on blood and urine tests for diagnosis.
- d) The testing for the presence of drugs in athletes and race horses helps promote fair competition.
- e) To ensure that swimming areas are free from contaminants or within acceptable limits, they must be regularly tested for contaminants.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) identification of unknowns (8e);
- b) ability to perform a practical laboratory test based on at least one of the student activities (8e);
- c) laboratory reports, especially in terms of accurate observations and logical inferences.

6. Safety Considerations

- a) Nitrates in the solid form should not be used in unknown samples if concentrated sulphuric acid is to be added directly in any of the tests, because of a possible violent reaction. Certain solid nitrate fertilizers are potentially explosive if heated, pounded, or added to concentrated acids.
- b) Note that certain reactions, such as that produced by mixing bleach with an acid medium, will produce a dangerous chlorine gas. A fume hood should be used for such activities.
- c) A hot-water bath should be used in testing for the presence of reducing sugars with Benedict's solution. Because of the corrosiveness of Fehling's solution, Benedict's is preferred. Glucose test strips are recommended for testing for the presence of reducing sugars.
- d) Hydrogen sulphide gas should not be used to test for reactions.
- e) Heavy metals present potential hazards when used in flame tests.
- f) A teacher demonstration is the preferred method of illustrating the testing for suspected contaminants, such as iodide in table salts.
- g) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) visit a forensic science or industrial laboratory;
- b) collect samples of water or snow from various locations for analysis;
- c) invite a quality-control chemist from a local industry to the class to demonstrate applications of industrial qualitative analysis;
- d) extend the qualitative analysis of a single sample to a comparison of several samples (e.g., an analysis for vitamin C in several kinds of juices).

8. Some Teaching Suggestions

- Teachers should ensure that the chemicals used in the samples for the analysis of cations and anions are water-soluble.
- This unit should be primarily activity-oriented, with students performing numerous investigations to determine the presence of substances in a variety of samples.
- A variety of problem-solving settings can be devised to heighten interest and relevance. If possible, these should relate to local situations (e.g., a local polluted body of water).
- An emphasis should be placed on proper laboratory techniques in arriving at reasonably accurate conclusions rather than the mere memorization of the chemical reactions involved.
- In the evaluation of student achievement, the practical laboratory test (5b) and the identification of an unknown (5a) can be combined. Because of the highly practical and activity-oriented nature of this unit, the evaluation of student achievement should also be practical and activity-oriented.
- Students should practise the techniques of filtering, decanting, transferring, evaporating, pipetting, and determining melting points in this unit.
- In order that students may work through this unit effectively and efficiently, it is suggested that the theory be kept to a minimum. Some simple nomenclature can be introduced. This nomenclature should be chosen to reflect the content of later units. It is not consistent with the expectations of this course in applied chemistry to deal with a large amount of theory at the beginning of the course.

Core Unit 2

The Structure of Matter

Time: 16 hours

In this unit students observe differences among the properties of various substances and attempt to explain these differences, using a scientific model. A review of flame tests and the examination of spectra lead to the Bohr-Rutherford concept of the atom. Students then examine trends in families of elements in the periodic table. The universal language of chemistry, with its symbols and nomenclature, is introduced in conjunction with a study of the periodic table.

This unit may be divided into topics such as the following:

- ▶ Elementary particles
- ▶ The Bohr-Rutherford model
- ▶ The periodic table
- ▶ Symbols

1. Objectives

Attitudes. Students will be encouraged to develop:

- an interest in the similarities among properties of certain elements and substances (2b, 3e);
- a respect for the usefulness of a model in science (2b, 2e, 3e, 5d);
- a curiosity about the trends in the classification of elements (2b-2e, 3e).

Skills. Students will have the opportunity to develop skill in:

- interpreting observations and recognizing regularities from data involving reactions with selected representative elements and families of elements from the periodic table (2b, 2c);
- inferring trends from reactions of members of a family of elements (2b-2e);
- comparing the physical properties of electrical conductivity, heat conductivity, and melting point of various elements (2b-2d);
- classifying elements as either metallic or non-metallic on the basis of some qualitative tests and simple reactions (2b, 2c);
- predicting the properties of an element by means of simple graphical analyses of other elements in the same family in the periodic table (2e).

Knowledge. Students will be expected to:

- state the features of the Bohr-Rutherford model of the atom (5d, 8e);
- state the names, symbols, and some characteristics of elements 1 to 20 and use the periodic table to draw Bohr-Rutherford diagrams for any of these elements (5d, 8c);
- define the following terms: element, compound, atomic number, mass number, atomic mass, isotope, ion;
- recall the flame tests used to identify common metallic ions (2a);
- compare the properties of elements within a family (2b-2e);
- define and give examples of a model and a theory (2e, 5d).

2. Student Activities

Students are to:

- review the flame tests of common metallic ions and observe the spectrum of at least one element (6a, 8a, 8b);
- observe and perform simple reactions that exhibit trends in reactivity for representative elements of groups I, II, and VII (5d, 8d);
- classify a variety of elements into categories, such as metallic and non-metallic, and according to their physical properties, including appearance, electrical conductivity, heat conductivity, melting point, lustre, and hardness (6b, 8c);
- perform simple combustion reactions with metals and non-metals, noting the effect on an indicator of the oxide when dissolved in water (6c, 6d, 8d);
- draw graphs of periodic trends of given data on chemical elements, use the graphs to predict the properties of elements, and illustrate the concept of periodicity (5c).

3. Applications

- Spectroscopic applications help to identify impurities in metallurgy.
- Radioactive isotopes of elements are used in processes such as carbon dating, medical diagnosis, and medical treatment and in such industrial applications as quality control in welding.
- Spectral analysis of the light from stars is used to determine the elements present in them.
- Discharge tubes may be used to produce images on a screen, as in an oscilloscope or a television set.
- Trends in the periodic table have allowed scientists to identify the properties of elements even before they have been discovered.

4. Societal Implications

- The cathode-ray tube, as applied in television and computer technology, has revolutionized communications.
- The use of the cathode-ray tube in computer monitors has resulted in considerable debate as to whether or not such monitors present a radiation health hazard.
- Radioactive materials, besides being useful in health treatment, can also pose a health hazard.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- laboratory skills as demonstrated during the activities;
- records of observations and interpretations of data from experimental work;
- constructions of simple graphs and interpretations of data from the graphs in activity 2e;
- demonstrated understandings of a scientific model, theory, and classification scheme.

6. Safety Considerations

- Students should be shielded from and exposed for a minimal time to discharge tubes that are involved in laboratory activities. The radiation specifications of the tubes should be checked before use.
- The power used for electrical conductivity categorizing should not exceed 12 V. A small dry cell should be used as the source of the power.

* See the subsection entitled "Student Activities" on page 5.

- c) When burning magnesium, students should look through a cobalt blue glass.
- d) The products of the combustion of sulphur and phosphorus are hazardous.
- e) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) investigate the relationship between radioactivity and nuclear stability;
- b) develop an activity series based on trends in the activity of several elements;
- c) observe a discharge tube in operation and interpret their observations.

8. Some Teaching Suggestions

- a) Hand-held spectrosopes or hand-held diffraction gratings are inexpensive and can be used to examine the spectra of elements.
- b) Students can make their own “firelog”, using solutions of the salts of various metals. Nitrate salts should not be used.
- c) As many of the elements as is practical should be displayed when students are classifying elements, learning their names and symbols, and drawing diagrams of the first twenty elements.
- d) Student activities 2b and 2d can be used to introduce concepts in core unit 5, “Acids and Bases”, and in optional unit 3, “Metallurgy”.
- e) Simulation activities involving macroscopic objects can give students a good understanding of the results of Rutherford’s gold-foil experiment.
- f) Films on the structure of the atom can be particularly useful in this unit.

Core Unit 3

Properties of Substances

Time: 17 hours

The structure of matter and its properties are determined by the atomic and molecular structure of its components. A knowledge of the structure of substances will enable students to understand better why materials react the way they do in everyday life. Some awareness of the structure of substances will also help students to begin to understand the basic chemical processes used in industrial manufacturing as well as those chemical processes found in living organisms.

This unit may be divided into topics such as the following:

- ▶ Physical characteristics
- ▶ Ionic bonding
- ▶ Covalent bonding

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation of the relationship between the properties of substances and the practical uses made of them (3, 4b);
- b) a curiosity about how the structure of matter affects its physical and chemical behaviour;
- c) a consideration for the impact of chemicals on the environment (4a, 4c).

Skills. Students will have the opportunity to develop skill in:

- a) determining the melting point of a solid and using this to identify various substances (2c);
- b) determining the melting-point range of a solid and using this as an indication of its purity (2c);

- c) using the periodic table or an ion chart to write simple ionic formulas (2e-2g, 5c);
- d) separating mixtures and purifying substances (2b);
- e) identifying a substance or the components of a mixture by using chromatography (2h).

Knowledge. Students will be expected to:

- a) describe the characteristic physical properties of ionic substances and of molecular substances;
- b) use the periodic table to predict the type of bonding that would occur between elements if they reacted to form a compound (2c, 2f, 5c);
- c) use data on the melting point or chromatographic results to establish the purity and probable identity of a substance (2b, 2h);
- d) give examples from everyday life of situations in which substances are used to lower the melting point of other substances (2c, 2i);
- e) describe some methods of separating a mixture into its “pure” components (2b, 2g, 2h);
- f) know and use in formulas the most common polyatomic ions, such as hydroxide, nitrate, acetate, ammonium, permanganate, sulphate, carbonate, and phosphate (2c-2f, 5c);
- g) write formulas for some simple binary and ternary compounds (2c-2f).

2. Student Activities

Students are to:

- a) investigate the physical characteristics of ionic and covalent compounds, for example, their solubility in water and other solvents, the electrical conductivity of their solutions, their cleaving behaviour, and their melting behaviour (6g, 8a);
- *b) carry out a separation of a mixture to obtain the “pure” components (6a);
- *c) (i) carry out a quantitative determination of the melting point of a pure molecular substance and of a mixture; (ii) use mixed melting points to establish the identity of a substance (6b, 8f);
- d) carry out an experiment to show the difference in chemical behaviour of differently charged ions of the same elements (8c, 8d);
- e) (i) prepare a covalent compound, such as carbon dioxide or acetylene; (ii) build molecular models of simple covalent compounds (6f);
- f) carry out a chemical reaction that produces a binary ionic compound (e.g., magnesium oxide) from its elements (6c, 8b);
- g) perform an experiment to illustrate the reaction between a common oxyacid and a metal to form a ternary salt;

- *h) use paper chromatography to separate a mixture of ions, inks, or dyes;
- i) investigate the freezing-point depression caused by adding specific amounts of (i) an ionic compound like salt to water and (ii) a covalent compound such as sugar to water.

3. Applications

- a) Ionic materials are used in electrochemical batteries, in electroplating, and in electroforming.
- b) The melting point of an organic material is often used to identify it. The sharpness of the melting point is also used as a quick, simple, and inexpensive way of establishing the purity of many substances used in the cosmetic, food, and detergent industries.
- c) The fact that adding a substance to a second material lowers the freezing point of that second material explains the use of salt to melt ice and the addition of chemicals to some industrial raw materials to liquefy them at room temperature.
- d) Liquid chromatographic separations of mixtures make use of the fact that certain substances are preferentially soluble in certain solvents. Chromatography is widely used in forensic work, in analytical research, and in micropreparations of chemicals.

4. Societal Implications

- a) Chemical spills and the improper disposal of waste chemicals sometimes cause severe environmental and health hazards. Examples include acid-rain problems, PCB disposal difficulties, and dioxin in the Great Lakes.
- b) The colour in many gems is partly the result of the presence of metal ions. Scientists have discovered that the treatment of inferior gems by atomic bombardment can change the colour of these gems. Some such gems have been passed off as natural gems and in some cases have been found to be radioactive.
- c) The use of salt on our roads in the winter enables us to use them in icy weather, but it causes severe damage to the cars we drive, to roadside vegetation, to rivers and lakes, and to the roads themselves.
- d) The common or trade names of chemicals do not indicate chemical composition. Different brand names may be used to sell the same product at different prices.

*See the subsection entitled “Student Activities” on page 5.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) skill and accuracy in obtaining experimental data (e.g., on melting points);
- b) written laboratory reports and class assignments;
- c) ability to write ionic formulas with the help of the periodic table.

6. Safety Considerations

- a) Students should use commercially prepared one-sided razor blades or scalpels to cleave crystals.
- b) The evaporation or heating of flammable solvents should be done in a water bath on a CSA-approved hot plate and preferably in a fume hood. Open flames and sparks should be kept away from flammable solvents.
- c) A thermometer should not be used as a stirring rod. A metal spatula, a wooden tongue depressor, a glass rod, or a wire hoop should be used. The use of mercury thermometers should be avoided.
- d) Students should be warned not to look directly at the flame of burning magnesium. They should view it through a cobalt blue glass.
- e) The vapours of naphthalene and per-dichlorobenzene are hazardous.
- f) Calcium carbide should be stored in a dry environment, as it is highly water reactive. Acetylene should be collected in test tubes, not in jars.
- g) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) carry out a silk-screen process and explain how the process works;
- b) investigate the freezing-point depression of antifreeze mixtures;
- c) prepare, purify, and quantitatively characterize an organic substance not prepared in this unit;
- d) build models of organic molecules to illustrate the common types of organic substances;
- e) use paper or column chromatography to separate the components of a consumer product.

8. Some Teaching Suggestions

- a) Rock salt works well to show the cleavage of ionic crystals. Chemicals such as salt and sugar can be used in the physical-properties experiment (activity 2a).
- b) In work on ion formation, the stability of the electron structure of the nearest noble gas can be used to explain the number of electrons gained or lost by an element when it reacts. Only the non-transition elements should be used.
- c) Iron(II) and iron(III) and tin(II) and tin(IV) can be used as examples of the differences in chemical behaviour of different ions of the same element.
- d) Students should not be involved in extensive molar calculations. They should be shown how they can apply the gram atomic masses on the periodic table to the formulas they have written to calculate the mass of one mole.
- e) Students should be supplied with ion charts rather than being required to memorize them for tests or examinations.
- f) The mixed-melting-point technique can be used to determine the identity of an unknown substance by mixing it with a sample of the substance it is suspected to be, that is, the control. If it is in fact that substance, the melting point of the mixture will be the same as that of the control substance.
- g) Teachers should relate what is happening in reactions to the periodic table whenever possible.

Core Unit 4

Chemicals in Action

Time: 13 hours

Chemistry deals largely with the interaction of chemicals in contact with one another, that is, with chemical reactions. Four types of reaction may be identified, and all of these have applications in industry and the household. When the teacher chooses practical examples of each type of reaction, students see not only a means of classifying reactions, but also the relevance of each type. Given the formulas involved in simple equations, students should develop skill in balancing equations, a skill that is fundamental to the basic language of chemists. Through laboratory activities, students will experience a wide variety of the techniques used in chemistry, thereby developing their manipulative skills as well as their knowledge of the subject.

This unit may be divided into topics such as the following:

- ▶ Synthesis
- ▶ Decomposition
- ▶ Single displacement
- ▶ Double displacement
- ▶ Chemical equations

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) an appreciation of the wide variety of situations in everyday life in which chemical reactions play a role (3a, 3b, 4a, 4b);
- b) an interest in classification schemes as a means of organizing information;

- c) a critical-mindedness towards the increasing number of chemical reactions used to produce new consumer products and towards their effect on the environment (4a-4c).

Skills. Students will have the opportunity to develop skill in:

- a) collecting and processing data, interpreting observations, and perceiving regularities from data related to reactions;
- b) safely handling chemicals and equipment in producing various types of reactions;
- c) transferring, filtering, and pipetting materials;
- d) precipitating and recrystallizing a product (2g, 5a);
- e) writing and balancing simple chemical equations that involve reactions encountered in this and other units (5b).

Knowledge. Students will be expected to:

- a) describe the law of conservation of mass as it applies to chemical reactions (2a);
- b) define and give an example of each of the four types of chemical reactions encountered (2b-2e);
- c) define or use the following terms: precipitate, filter, filtrate, residue, decant, transfer, pipette, recrystallization, evaporation, synthesis, decomposition, single- and double-displacement reactions;
- d) use chemical terms and symbols correctly (8c);
- e) define and give an example of an exothermic and an endothermic reaction (2f).

2. Student Activities

Students are to:

- a) perform an experiment to illustrate the law of conservation of mass (8a, 8b);
- *b) perform a synthesis reaction, such as the formation of magnesium oxide (6c, 8a, 8b);
- *c) perform a decomposition reaction, such as the decomposition of calcium carbonate (6a);
- *d) perform a single-displacement reaction, such as the displacement of copper(II) ion from copper(II) sulphate or copper(II) oxide by zinc;
- *e) perform a double-displacement reaction, such as the precipitation reaction of silver nitrate with an impurity in tap water;
- *f) perform an experiment to illustrate endothermic and exothermic processes;
- *g) perform an experiment involving precipitation, recrystallization, and filtration.

*See the subsection entitled "Student Activities" on page 5.

3. Applications

- a) Polymers (e.g., polypropylene, polyesters, nylon) are produced as a result of addition or condensation syntheses.
- b) The industrial preparation of metals depends on one of two types of reaction: (i) a decomposition reaction, such as electrolysis, or (ii) a single-displacement reaction, such as roasting.
- c) The laboratory production of elements is often the result of a single-displacement reaction (e.g., the production of hydrogen by the reaction of zinc with hydrochloric acid).
- d) Equations form the language used by chemists to communicate the results of reactions. Equations may be used to help represent many household and industrial reactions (e.g., fermentation, acid-rain production, rusting).

4. Societal Implications

- a) Many chemical reactions produce useful products, for example, acetylsalicylic acid (ASA). Some chemical reactions result in harmful products such as rust.
- b) Such industrial chemical reactions as the roasting of sulphide ores produce materials valued in society but at the same time pollute the environment.
- c) Some air pollution from automobiles is the result of synthesis reactions.
- d) Common or household names for chemicals do not indicate chemical composition. Different brand names may be used to sell the same chemical product at different prices.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) ability to perform a practical laboratory test based on a procedure such as filtration, precipitation, or recrystallization;
- b) ability to balance chemical equations for reactions involved in this unit and previous units;
- c) collection and interpretation of data in their laboratory reports.

6. Safety Considerations

- a) If the synthesis of magnesium oxide is performed, students should not look directly at the burning magnesium. They should view it through a cobalt blue glass.
- b) Since copper(II) carbonate is poisonous, calcium carbonate is recommended as an alternative.
- c) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) perform several simple synthesis reactions (e.g., the combustion of elements) and write equations for these reactions;
- b) carry out an organic synthesis reaction, such as addition or condensation polymerization;
- c) visit a smelter to observe the smelting operation;
- d) determine the percentage yield of a product in a precipitation reaction;
- e) do simple quantitative calculations, using balanced chemical equations.

8. Some Teaching Suggestions

- a) Throughout this unit students should be actively involved in performing activities and producing their own chemical reactions. Teachers should ensure that, within a group, students rotate the roles of experimenter and recorder.
- b) Simple relevant reactions selected from the home, from hobbies, or from industry should be used as examples. Students should attempt to categorize these reactions in terms of similar patterns of reactants and products.
- c) Students can use examples of reactions from previous units to gain experience in balancing equations. In general, equations should illustrate the reactions encountered in the course.
- d) The following techniques should be included in this unit wherever they are appropriate: filtering, decanting, transferring, evaporating, pipetting, and determining melting points. To this end, activity 2g can be combined with some of the other activities.

Core Unit 5

Acids and Bases

Time: 16 hours

This unit is designed to provide students with sufficient knowledge of pH so that they can understand the role of acids and bases in such consumer products as cleansers, personal-care products, foods, baking ingredients, drugs, and confectionery products.

This unit may be divided into topics such as the following:

- ▶ Consumer products
- ▶ The pH scale
- ▶ Properties of acids and bases
- ▶ Household indicators
- ▶ Oxygen and acids and bases
- ▶ Acid-base reactions
- ▶ Titrations

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a concern about the effect of acid rain on the environment (4b);
- b) an interest in the extensive role that acidic and basic substances play in everyday life and in the manufacturing sector of the economy (3, 4);
- c) an awareness of the safety hazards and precautions associated with acids and bases (6);
- d) a commitment to following all safety directions on chemical or consumer-product containers (2a, 2b, 2d).

Skills. Students will have the opportunity to develop skill in:

- a) safely handling acids and bases and other chemicals (2, 6);
- b) preparing, collecting, testing, and identifying acidic, basic, and neutral substances;
- c) operating gravimetric and volumetric equipment such as a pH meter (5c);
- d) carrying out a titration and other acid-base quantitative experiments (2a-2d, 2h);
- e) accurately preparing and diluting volumetric solutions (2a).

Knowledge. Students will be expected to:

- a) describe some properties of acids and bases and outline ways to prepare them experimentally and to test for their presence;
- b) describe precautions to be taken when working with acids and bases and other chemicals involved in acidic or basic reactions;
- c) describe the role of indicators in acid-base chemistry and give some examples (2a, 2c-2f);
- d) describe the pH scale, relating numerical values to the terms *neutral*, *acid*, and *base* (2a, 2g);
- e) describe the significance of pH in a number of household and consumer products (2a, 2d, 2e, 2h);
- f) write names and chemical formulas for common acids and bases (2a-2c, 2e, 2f);
- g) define and give some simple examples of *neutralization* (2c-2e);
- h) write word equations and balanced chemical equations for the reactions carried out in this unit (2b, 2c, 2e, 2f, 5d).

2. Student Activities

Students are to:

- *a) (i) test a number of consumer products with three indicators to establish if they are acidic, basic, or neutral and (ii) use pipettes to carry out a series of dilutions of a strong acid and a strong base and use these dilutions and the universal indicator to relate the colours to acid or base concentrations and approximate pH values (6a, 6b, 8a, 8b);
- *b) (i) establish some properties of acids and bases, using both laboratory acids and bases and household (consumer) acids and bases, and (ii) test any gaseous by-products of these reactions to establish chemical tests for carbon dioxide, ammonia, and hydrogen (5b, 8c);
- *c) (i) make a typical strong acid and a typical strong base react to form a salt and water and (ii) carry out a quantitative titration of a strong acid and a strong base (5a, 8f);

*See the subsection entitled "Student Activities" on page 5.

- d) carry out a quantitative acid-base titration on a consumer product, for example, vinegar, antacid tablets, milk, window cleaner, or household ammonia (5a, 8f);
- e) test the effect of acids and bases on (i) various coloured household indicators and (ii) the colour and texture of green vegetables when they are being cooked (5b);
- f) (i) prepare oxygen, (ii) burn non-metals and metals in oxygen, and (iii) mix the resulting oxides with water and test the aqueous product with the universal indicator (6c-6e, 6j, 8e, 8i);
- g) use a pH meter to measure the pH of various consumer products, such as shampoo, fruit juices, milk products, and carbonated beverages (8h);
- h) carry out a titration of various antacids (5a, 8d, 8f).

3. Applications

- a) The correct acidity of food products controls bacterial growth.
- b) Since strongly basic solutions destroy protein fibres, such as hair, wool, and silk, the pH of products for washing these fibres should not be too high. Manufacturers of shampoos, hair conditioners, and fine-fabric cleaners take this into account.
- c) The reaction of acidic salts or acidic substances with carbonates or bicarbonates is used to produce carbon dioxide gas in the leavening of baked goods.
- d) The pH of swimming-pool water must be carefully monitored, since it varies with the addition of chemicals from the environment and from swimmers. Also, in a marbelite or plastered pool, a low pH can result in the disintegration of the pool's walls.
- e) Products such as oven cleaners, drainpipe openers, and window cleaners, which are grease-removal chemicals, are usually very basic.

4. Societal Implications

- a) Many careers as a technician or technologist in analytical quality-control and quality-assurance laboratories require a knowledge of the chemistry of acids and bases, skill in dilution and titration techniques, and the ability to use a pH meter accurately.
- b) Acid rain is a result of the non-metal oxides produced in our industrial and energy-demanding society. Acid rain is known to cause a great deal of damage to building materials, works of art, and the environment. Long-term damage can seriously affect all creatures that live in that environment.
- c) The "pH" of shampoo, "buffers" in ASA products, and the "acid-destroying power" of antacid tablets are examples of scientific terms used in advertising. Legislation exists to control the claims made by advertisers.

- d) Acid spills can be neutralized by basic substances, or vice versa, but care must be taken in the choice of the bases or acids used. The method of treating chemical problems (e.g., in the environment or on the skin) must be selected with great care, since it can cause more problems than it solves.
- e) All living things are sensitive to acids and bases. For this reason industries keep a close check on the pH of their products. It is particularly important in the pharmaceutical, cosmetic, personal-care, and food-product industries, since many products are applied directly, either externally or internally, to people and other forms of life.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) ability to perform a practical test involving a titration (technique, accuracy, and the recording of data should be stressed);
- b) records of observations on the properties of acids and bases;
- c) use of gravimetric and volumetric equipment;
- d) ability to balance some simple chemical equations.

6. Safety Considerations

- a) When testing consumer products, students should not mix any of these products together without explicit instructions.
- b) Extreme heat is created when water is added to a powdered drain cleaner. Caution should be observed because the gas produced is usually hydrogen.
- c) Students should be warned not to look directly at the light emitted from burning magnesium. They should view it through a cobalt blue glass.
- d) The burning of sodium, if performed in activity 2f, should be demonstrated by the teacher. The burning of sulphur and phosphorus should be performed in a fume hood.
- e) It is recommended that hydrogen peroxide (3-6 per cent) and manganese dioxide (pyrolusite) be used in place of potassium chlorite.
- f) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) develop a testing procedure to establish the efficiency of a window cleaner and compare this cleaner with two or more other similar consumer products;
- b) use an acidic substance, such as nitric acid or ferric chloride, to etch a design or circuit on copper; nitrogen dioxide will be produced in the reaction involving nitric acid and copper; students should use direct local ventilation (e.g., a fume hood);
- c) investigate the relationship between pH and the colours of cocoa, chocolate-drink mix, or chocolate cake;
- d) test the effect of sulphuric or sulphurous acid on materials that simulate outdoor building materials and outdoor art materials, such as marble, bronze, and ceramics;
- e) compare the leavening (gas-producing) ability of various types of acid salts when they react with sodium bicarbonate, both at room temperature and at elevated temperatures;
- f) investigate the effect of the addition of small amounts of an acid and a base on the pH of both a buffered solution and a non-buffered solution (8g).
- f) When doing the titration with antacid tablets, students can perform a back titration, using phenolphthalein as the indicator. When doing a titration with ammonia-based products, they can use bromocresol green, methyl red, or phenolphthalein as the indicator.
- g) When investigating the effect of acids and bases on buffers in extension 7f, students can compare a buffer solution having a pH of 7 and freshly boiled distilled water. The additions of acid or base should be small, otherwise the buffer system can be destroyed. If buffers are introduced, they should not be treated quantitatively.
- h) When using the pH meter on shampoo, students can test straight shampoo and a 1 per cent solution. One per cent dilutions of solid products can also be used. Undiluted liquids, such as milk, buttermilk, yogurt, ice-cream melt, carbonated drinks, and fruit juices, are also appropriate.
- i) Activity 2f can be treated as a review and further extension of activity 2d in core unit 2.

8. Some Teaching Suggestions

- a) In the consumer-product experiment, activity 2a, distilled water and dilute solutions of a representative strong acid and a strong base, together with the indicator, should be used to establish the indicator colours in neutral, acidic, and basic conditions. Universal indicator, wide-range pH paper, phenolphthalein, and bromthymol blue can be used as indicators. A powdered drain opener can serve as one of the examples of a basic substance, since this relates to the reaction of aluminum and sodium hydroxide. A soap can also be used as a sample basic substance.
- b) In the dilution experiment, activity 2a(ii), the universal indicator can be used with the dilutions to show the relationship between an acid or a base concentration, the indicator colours, and the pH scale.
- c) Washing soda (sodium carbonate) and baking soda (sodium bicarbonate) can be used instead of laboratory chemicals to provide typical reactions of acids and bases.
- d) If standard volumetric apparatus is not available, satisfactory titrations can be performed with eye droppers.
- e) Sodium, magnesium, iron, carbon, phosphorus, and sulphur are examples of elements that may be burned. Precautions are outlined in 6d. Teachers should ensure that students use extremely small amounts of elements such as phosphorus and sulphur and that they use the fume hood. The universal indicator gives the best results in the testing of aqueous solutions of the products of combustion.

Optional Unit 1

The World of Carbon Chemistry

Time: 16 hours

This topic can be used as an introduction to basic organic chemistry. The world of organic, or carbon, chemistry has tremendous diversity, breadth, and range and includes numerous compounds that arise from living organisms, organisms that once lived, and a variety of non-living sources. The chemistry of oil, one of Canada's major resources, is an example of the importance of this type of chemistry.

This unit may be divided into topics such as the following:

- ▶ Hydrocarbons
- ▶ Cracking and reforming
- ▶ Saturation and unsaturation
- ▶ Distillation
- ▶ Pollution

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a curiosity about the scope of carbon chemistry and the impact that it has on our lifestyle (3,4);
- b) an interest in the various carbon compounds found in oil (2a).

Skills. Students will have the opportunity to develop skill in:

- a) measuring temperatures of various fractions in the distillation of crude oil (2a);
- b) recording data from the distillation-of-oil experiment;
- c) following procedures in order to perform an experiment to produce organic compounds (2b, 2d, 2f-2h);
- d) classifying the different forms of hydrocarbons into their various groups.

Knowledge. Students will be expected to:

- a) describe and explain the distillation of crude oil (2a, 8a);
- b) match the fractions obtained from the distillation of crude oil with their consumer uses (2a);
- c) state or use the IUPAC (International Union of Pure and Applied Chemistry) names, formulas, and structures of a number of basic organic compounds (2b-2g);
- d) state the characteristic properties of some of the compounds with specific functional groups that are identified in experiments and observations selected from the student activities (2b-2g).

2. Student Activities

Students are to:

- *a) perform an experiment to distil a small sample of crude oil, taking off four or five fractions (5b, 6d, 8a);
- b) perform an experiment (fractional distillation) to produce either ethyne (acetylene) or ethene and test it for unsaturation (6b, 8c);
- c) examine common hydrocarbons, such as methane, propane, butane, ethyne, kerosene, and candle wax and examine each hydrocarbon by (i) burning, (ii) shaking with bromine water, and (iii) adding a drop of concentrated sulphuric acid (6b, 6d, 8b);
- d) perform an experiment to test for some properties of the homologous series of alcohols; use some common alcohols, such as methanol, ethanol, propanol, butanol, and hexanol; and carry out tests to determine attributes such as the following: melting point; boiling point; density; reaction with sodium, acetic anhydride, and oxidizing agents (6a, 6b, 6d, 6e);
- *e) perform an experiment to make alcohol by fermentation; *or* perform an experiment (i) to react ethanol with acetic acid to make ethyl acetate (highly flammable) and (ii) to make a second ester such as methyl salicylate (oil of wintergreen, which is very poisonous) (6c); *or* perform an experiment to make iodoform (6e, 8d);
- f) perform an experiment to illustrate the different methods of dyeing fabrics (5b, 8e).

3. Applications

- a) The raw materials for thousands of products used in daily life (e.g., antifreeze, polythene) are derived from crude oil.
- b) Other substances, apart from gasoline, that are produced by an oil refinery include jet fuel, diesel fuel, kerosene, waxes, asphalt, greases, lubricating oils, and tar.

*See the subsection entitled "Student Activities" on page 5.

- c) Raw materials for the petrochemical and pharmaceutical industries are derived from oil distillation.
- d) Carbon chemistry is the basis of life on earth.
- e) Careers in biology, biochemistry, and medical technology require a knowledge of organic chemistry.

4. Societal Implications

- a) Canada has large reserves of crude oil in the Athabasca oil sands, which are important to our future supplies of oil. However, the oil has properties that are different from those of conventional crude oil, and special technology and a lot of energy are required to extract it from the sands.
- b) Some of the additives to gasoline (e.g., lead tetraethyl) become pollutants after combustion.
- c) Saturated edible oils are suspected as contributors to heart disease.
- d) Plastics and synthetic materials are widely used by-products of the oil industry and have greatly affected our lifestyle.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) safe and skilful laboratory work;
- b) submission of samples from the activities (e.g., samples from the crude-oil distillation labelled with temperature ranges or the results of dyeing various fabrics);
- c) records of data from experiments.

6. Safety Considerations

- a) Organic compounds that are carcinogenic or unduly hazardous should not be used.
- b) If bromine water is used in activity 2b, a very dilute solution that is just yellow in colour should be employed. A 1 per cent solution of potassium permanganate may be used to test for unsaturation.
- c) A teacher demonstration is preferred for the testing for suspected contaminants such as iodide in table salts.
- d) The evaporation or heating of flammable solvents should be done in a water bath on a CSA-approved hot plate and preferably in a fume hood. Open flames and sparks should be kept away from flammable solvents.
- e) Adequate positive (active) ventilation should be provided for the evaporation of alcohols, as well as for their short-term exposure to the air.

- f) Water-based dyes are highly recommended.
- g) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- a) organize a trip to a factory or plant that utilizes organic chemistry in its processes (e.g., an oil refinery);
- b) carry out experiments to synthesize a perfume;
- c) carry out experiments to make various forms of plastic;
- d) carry out experiments to make cellulose fibres;
- e) discuss the economic, political, and practical problems associated with dwindling oil supplies.

8. Some Teaching Suggestions

- a) In preparing iodoform in activity 2e, household bleaching solutions can be substituted for sodium hypochlorite solution.
- b) Different types of dyeing can be tried in activity 2f, including the following: direct dyeing, mordant dyeing, vat dyeing, developed dyeing.

Optional Unit 2

The Chemistry of Consumer Products

Time: 16 hours

Chemistry plays an important role in the manufacturing of almost all of the products that are available to today's consumers and artisans. Even those using natural materials are using chemicals that are in, or have been extracted from, natural sources. Extraction may be done either by chemical or physical means or by a combination of both.

In the development of any product, a great deal of chemical and physical testing is done on the raw materials; many scientific principals are employed in the manufacture of the product, which is constantly monitored during and after manufacture to ensure that its materials are acceptable and that it functions satisfactorily. This means that a knowledge of science, including chemistry, is essential in the manufacturing sector of industry and to anyone planning a career in this sector.

Consumers of industrial products are also well advised to understand the elements of chemistry. They are then in a better position to assess the worth of a product, evaluate claims made about it, understand directions and safety features in its use, appreciate reasons for additives, and implement proper maintenance of the product.

This unit may be divided into topics such as the following:

- ▶ Classification of matter
- ▶ Surfactants
- ▶ The cleaning and laundry-product industry
- ▶ The personal-care and cosmetic industry
- ▶ The confectionery industry
- ▶ The food industry
- ▶ The pharmaceutical industry
- ▶ The craft and art world

1. Objectives

Attitudes. Students will be encouraged to develop:

- a) a curiosity about career opportunities in chemistry and the chemical industry (4a);
- b) a questioning attitude towards real or imagined needs for additives in consumer products (2c, 3a, 4b);
- c) a respect for the directions on consumer products and the instructions about safety precautions, as well as an awareness of ingredient listings (4f);
- d) an analytical attitude towards advertisements and promotions of consumer products (3c, 4d, 4f).

Skills. Students will have the opportunity to develop skill in:

- a) classifying consumer products (2a);
- b) observing the behaviour and analysing for the presence of chemicals that are important in industry and the arts (2a, 2b);
- c) using volumetric equipment, such as pipettes, burettes, and balances, in the quantitative analysis of consumer products (2b, 2e);
- d) using a pH meter and, where available, such instruments as a refractometer, centrifuge, colorimeter, and viscometer (2b-2f);
- e) carrying out sensory evaluation of colours, fragrances, and flavours (2a).

Knowledge. Students will be expected to:

- a) describe the preparation of a consumer product that they have made or analysed, explain the chemical nature and role of the main ingredients and additives in the product, and, where possible, explain the chemical processes involved in the use of the product (2b-2f);
- b) recognize and describe industrial or consumer products that are examples of solutions, dispersions, gels, emulsions, emulsifying agents, surfactants, and oxidizing agents (3a, 3b, 3d).

2. Student Activities

Students are to:

- a) classify a number of laboratory and consumer products according to their physical and chemical properties (8a);
- *b) (i) test the action of household bleach on various types of fibres and dyed fabrics and (ii) determine the percentage of sodium hypochlorite in household bleach by titration with sodium thiosulphate (5c, 8b, 8f);
- *c) (i) prepare a consumer product, such as a window cleaner, wood polish, car wax, windshield-washer liquid, aftershave lotion, toothpaste, shampoo, eyeshadow, or men's gel cologne,

*See the subsection entitled "Student Activities" on page 5.

- or (ii) prepare an emulsified personal-care product, such as hand cream or cleansing cream, and test the product and several other consumer products to establish whether they are oil-in-water or water-in-oil emulsions (5a, 6a, 6d, 6e, 8a, 8e);
- *d) (i) determine the percentage of available atomic chlorine in a household abrasive cleaner by titration with sodium thio-sulphate; (ii) determine the pH of a centrifuged 1 per cent mixture of an abrasive cleaner and water; and (iii) determine the percentage of abrasive material present (6c, 8f);
- e) determine the percentage of sodium chloride in salted butter by titration with silver nitrate (8d, 8f);
- f) investigate the chemical patination (chemical colouring of the surface) of metals (6a).

3. Applications

- a) Hypochlorite bleach is used in swimming pools, in water-purification plants, and as a disinfectant.
- b) The cosmetic industry and the food industry produce a great number of products that are emulsions (e.g., mayonnaise, ice cream, hand cream, cold cream).
- c) Titrations to find the free fatty-acid content, the iodine number, and the saponification number of fats or oils are routine tests that are done in the detergent, cosmetic, and food industries. These values indicate the quality and suitability of the materials for practical use.
- d) Surfactants are used in detergents, fabric softeners, anti-spot dishwasher rinses, salad dressings, bread, ice cream, non-dairy creamers, yarn and textile dyeing, and many other products and processes.
- e) The glazing of pottery or ceramics, the production of glass and plastics, and the gluing together of substances involve the use of chemicals. Research into these processes requires a substantial knowledge of chemical components and their characteristics.
- f) Flavours, fragrances, and colours are derived from chemicals and play an important role in industry and society.

4. Societal Implications

- a) Many thousands of people are employed in the manufacturing and art-related sectors of our economy. A background in basic chemistry is an asset for a person working in these sectors.
- b) Additives very often improve a product in one or more of the following aspects: shelf life, consumer acceptability, safety, and quality. Some additives have also been shown to be harmful for some people (e.g., red dye #2).

- c) "New and improved" is often used as a slogan for a product. This may or may not mean a significant improvement, and the quality being improved may not actually be identified.
- d) Colour, odour, and outer packaging play an enormous role in product promotion, and yet these factors are really ancillaries, which often are unnecessary for the operation or use of the product.
- e) Natural drugs, flavours, and fragrances are not necessarily better or safer than synthetic ones.
- f) In Canada labels carry directions and safety information for the consumer, but the ingredients do not have to be listed in the order of amount. Students should recognize, however, that labelling adds to the cost of a product.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) presentation of products in the student activities, especially in regard to the quality of their preparations;
- b) written class assignments and laboratory reports;
- c) titrimetric skills and accuracy in activity 2b.

6. Safety Considerations

- a) Many consumer products are corrosive, and thus the same precautions should be taken with them as with laboratory chemicals.
- b) If flammable liquids are used or heated, hot plates in a water bath must be used; there should be no open flames in the classroom.
- c) Students should be warned to avoid breathing the dust of a powdered abrasive cleaner.
- d) Glass thermometers should not be used as stirring rods. A metal spatula, wooden tongue depressor, wire loop, or glass rod should be used instead.
- e) The use of commercially produced personal-care products by students should be restricted to the skin testing of the product on a small unsensitive area of the hand. Students should not use any of the products that they produce in the laboratory because they cannot know the purity of such products. Students should be surveyed regarding any known allergies at the outset of the activities.
- f) For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

*See the subsection entitled "Student Activities" on page 5.

7. Possible Extensions

Some students might:

- use chemical dyes to dye fabrics made of protein, cellulose, and synthetic materials;
- use natural dyes, together with chemical mordants, to dye natural fibres;
- develop photographic film, having made up all the required solutions;
- research a consumer product, prepare it, name it, bottle it, and construct a package for it; decide on the target market for the product; cost it for both the wholesale and retail market; and set up a marketing strategy and calendar for the product;
- carry out a series of chemical tests to investigate the suitability of a given plastic material for use in making a container for a given product;
- make up a pottery glaze and kiln-test it on several clay bodies;
- prepare a pigment and use it to make a paint or pastel stick;
- investigate the chemistry of photography;
- carry out some fragrance-matching tests or flavour-preference tests.

8. Some Teaching Suggestions

- A chemical, cosmetic, or household formulary book is a good resource for descriptions of ingredients and methods for preparing consumer products. Products that will appeal to both males and females should be prepared. Students might be required to use consumer magazines to prepare a report on a household product.
- In iodimetric titrations, the starch indicator can often be omitted, especially if the product has little or no colour, as in activity 2b.
- The sodium salt of nitrilotriacetic acid is a cleaning agent that is used to replace phosphate where the government regulates a low-phosphate content in detergents.
- Potassium chromate is used as the indicator in the determination of the percentage of salt in butter.
- A sensory evaluation booklet is available from the Communications Branch of Agriculture Canada in Ottawa.
- If standard volumetric apparatus is not available, satisfactory titrations can be performed with droppers.

Optional Unit 3

Metallurgy

Time: 16 hours

The concepts of oxidation and reduction are important to the understanding of chemistry. If the concepts are presented through their applications, students will not only learn the applications but also have a practical understanding of the basic concepts. A thorough grasp of these concepts is necessary for further study in chemistry and technology.

This unit may be divided into topics such as the following:

- ▶ Activity series
- ▶ Corrosion
- ▶ Electrolysis
- ▶ Chemical cells
- ▶ Oxidation and reduction
- ▶ Hydrogen
- ▶ Galvanizing and tin plating

1. Objectives

Attitudes. Students will be encouraged to develop:

- a curiosity about the many applications and implications of oxidation and reduction;
- an appreciation of the place of electrolysis in the history of chemistry (3c, 3d, 4b);
- an interest in scientific reporting related to the industrial applications of oxidation and reduction (2g, 8f).

Skills. Students will have the opportunity to develop skill in:

- classifying metals in their order of activity (2a);
- predicting the products of electrolysis of an aqueous solution of an ionic salt (2b);

- c) interpreting data from experiments in order to classify metals according to whether they will or will not protect iron from corrosion (2c);
- d) inferring factors that affect the rate of corrosion (2c);
- e) manipulating variables in experiments in order to compare the activity of metals (2a);
- f) interpreting the colour changes of an indicator to explain the chemical changes involved in the corrosion of iron (2c);
- g) retrieving, reading, evaluating, analysing, and reporting on scientific information related to industrial applications of oxidation and reduction (2g).

Knowledge. Students will be expected to:

- a) write balanced chemical equations for the reactions studied in this unit that involve metals and their interaction with (i) water and steam, (ii) dilute acids, and (iii) dilute solutions of metal salts (2a, 8a);
- b) list selected metals and hydrogen in order of activity (2a);
- c) determine which metals accelerate and which metals inhibit the corrosion of iron and give practical examples of each case (8a);
- d) state the reasons for galvanizing and tin-plating (2c);
- e) state the meaning of the following terms: oxidation, reduction, anode, cathode, electrolyte, salt bridge;
- f) describe and explain the electrolysis of solutions of ionic salts and related industrial processes (2b);
- g) describe a chemical cell using two different metals as electrodes and explain how it functions (2d, 8d);
- h) describe methods of preparing hydrogen gas, list properties and uses of hydrogen gas, and relate the uses to the properties (2a, 2e).

2. Student Activities

Students are to:

- *a) perform an experiment to observe the reaction of metals with water and steam, dilute acids, and aqueous solutions of metal salts (6a, 6e, 8a);
- *b) observe the effects of passing an electric current (no more than 12 V) through an aqueous solution of an ionic salt;
- *c) observe the corrosion of iron when it is connected to various metals and note the direction of the electric current flow between the metals; *or* observe the effect of an applied electric current on the corrosion of iron; *or* observe the effects of aeration on the corrosion of iron (8a-8e);
- *d) perform an experiment to investigate (i) the voltages produced by various metal combinations and (ii) the chemical changes that take place in an electrochemical cell;

- e) collect hydrogen gas and determine some of its properties (6b);
- f) perform an experiment to (i) transfer copper from anode to cathode through a copper(II) electrolyte *or* (ii) show the silver-plating of a copper object (the cyanide technique for silver-plating should be avoided);
- *g) complete an assignment on an industrial application of redox (5b, 8f).

3. Applications

- a) Processes for the prevention of corrosion are used to protect car bodies, pipelines, bridges, piers, and ships.
- b) Displacement reactions are used in the industrial preparation of several metals (e.g., titanium).
- c) Electrolysis is used in the production of several metals and some non-metals.
- d) Electrolysis is used in purifying metals (e.g., electroplating).
- e) Anodizing not only increases aluminum's resistance to corrosion but also can be used to apply a coloured dye to the metal.

4. Societal Implications

- a) Corrosion damage costs society millions of dollars each year.
- b) Electrolysis is a method that is used in Canada to produce and refine metals. The method determines the location of the industry, since large amounts of electrical energy are needed.
- c) The issue of aluminum cans versus steel cans requires much debate. Aluminum cans require more energy to produce, are less dense, take longer to corrode in the environment, and can be recycled at a smaller energy cost.
- d) The problem of producing an electric car that will be non-polluting and have a suitable range is a technological challenge.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) practical laboratory work;
- b) projects on an industrial application of the principles of redox;
- c) records of observations and interpretations from laboratory work.

*See the subsection entitled "Student Activities" on page 5.

6. Safety Considerations

- The reaction of the metals, sodium, potassium, and lithium with water should be demonstrated by the teacher. Safety shields should be used.
- The teacher should demonstrate the reaction of magnesium with steam.
- Small quantities of hydrogen should be used in testing for the gas.
- If chlorine, bromine, or iodine is produced in electrolysis, a fume hood should be used to prevent the release of the gas into the room.
- For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- visit a smelter;
- invite a speaker from a local car-rustproofing agency to speak to the class;
- investigate electroplating, anodizing, and other methods of preventing corrosion;
- compare the use of non-inert electrodes with the use of inert ones in electrolysis;
- investigate the corrosive effects of acid rain and road salt on various kinds of structures (e.g., cars, bridges, buildings, trees);
- outline the part played by electrolysis in the discovery of the alkali metals and the alkaline earth metals.

8. Some Teaching Suggestions

- It is important that students understand the activity series before they attempt work on corrosion, electrolysis, and chemical cells. The activity series can be explained in terms of the ease with which a metal loses an electron.
- The recommended indicator for the corrosion experiments (activity 2c) contains phenolphthalein and potassium ferricyanide.
- U-tubes are very useful pieces of equipment in this series of experiments.
- Corrosion, electrolysis, and chemical cells can be taught in any order.
- In activity 2c, for the observation of the effects of aeration, a suitable metal other than iron should be used as a control (e.g., copper).
- Co-operative planning should take place with the school's librarian to ensure that (i) resources are available on industrial applications of oxidation-reduction and (ii) students have the retrieval skills necessary to do activity 2g.

Optional Unit 4

Nuclear Chemistry

Time: 16 hours

The purpose of this unit is to provide students with a knowledge about simple nuclear reactions so that they can make informed decisions when dealing with nuclear issues.

This unit may be divided into topics such as the following:

- ▶ Radioactivity
- ▶ Half-life
- ▶ Radiocarbon dating
- ▶ Nuclear fission
- ▶ The CANDU reactor
- ▶ The atomic bomb
- ▶ The history of the atom

1. Objectives

Attitudes. Students will be encouraged to develop:

- objectivity in assessing the arguments about nuclear power (2c);
- a respect for the contributions of scientists in developing modern atomic theory (2e);
- an appreciation of both the benefits and hazards of atomic radiation (3a, 3c, 3e, 4a);
- a concern for the effect of a nuclear explosion on animals, plants, structures, and people (4b);
- an appreciation of the diverse applications of nuclear technology (3a, 3b).

Skills. Students will have the opportunity to develop skill in:

- a) drawing a half-life graph for an isotope of known half-life (2a, 5a);
- b) estimating from a half-life graph the activity of an isotope after a given time and the time it takes to reach a given activity (2a);
- c) calculating the age of a fossil from a carbon 14 half-life graph (2b, 5b);
- d) interpreting a simple nuclear equation;
- e) organizing arguments in order to discuss the pros and cons of nuclear energy (2c);
- f) reporting from a search of the school's library resource centre (or some other library) the history of the development of the nuclear model of the atom from about 1890, including Canadian contributions to its development (2e).

Knowledge. Students will be expected to:

- a) state the mass number, atomic number, charge, and relative penetrating power of an alpha particle, a beta particle, and a gamma ray;
- b) compare the damage done to the body when it is hit externally by alpha particles, beta particles, and gamma rays;
- c) compare the relative effects on the body of external and internal bombardment by atomic radiation;
- d) list the contributions to the development of atomic theory by some key scientists, such as Becquerel, the Curies, Rutherford, Hahn, and Fermi (2e, 8d);
- e) define or use the following terms: half-life, fission, critical mass, moderator, chain reaction, fall-out, breeder reactor;
- f) state the problems caused by the disposal of spent fuel from an atomic reactor, such as the CANDU reactor (2c, 2f);
- g) list the short- and long-term effects of a nuclear explosion;
- h) state the major sources of background radiation;
- i) state the major factors that affect the radiation dosage that a person receives.

2. Student Activities

Students are to:

- *a) construct a half-life graph and determine from the graph the activity values at any time, as well as the time taken to reach a certain activity (5a, 8a);
- *b) construct a carbon 14 half-life graph, given the pertinent data, and use the graph to calculate the age of a fossil (5b);
- *c) participate in a class discussion on the pros and cons of using nuclear energy or develop a project on an aspect of nuclear chemistry (5c);

- *d) perform a simulation exercise, using ceramic magnets to illustrate radioactivity; *or* use a cloud chamber to observe the traces of alpha and beta particles; *or* draw a simple diagram of a CANDU reactor; *or* use a Geiger counter to investigate the penetrating power of alpha particles, beta particles, and gamma rays (6b, 8a, 8b);
- *e) prepare a report on the history of the development of the nuclear model, including Canadian contributions to its development (8d);
- f) visit a nuclear reactor, or carry out a computer simulation of a nuclear reactor, or view a film or videotape of a nuclear reactor, or read a good account of a nuclear reactor;
- g) compare experimentally the growth of irradiated seeds and non-irradiated seeds.

3. Applications

- a) Radioactive isotopes (e.g., cobalt 60, iodine 131) are used as tracers in such fields as medicine and biological research.
- b) Neutron-activation analysis is a tool used in forensic science.
- c) Radiation is used as a sterilizing agent.
- d) Nuclear fission produces vast amounts of energy per unit mass.
- e) The cobalt bomb, used in cancer treatment, is a Canadian invention.

4. Societal Implications

- a) Radiation can cause cancer and leukemia in humans. Atomic energy is expensive to develop, and there are problems in storing spent fuel. However, coal-fired power stations cause acid rain. Problems such as these must be dealt with in decisions about the future production of electrical energy.
- b) The effects of dropping an atom bomb have been well documented, on the basis of data obtained from Hiroshima and Nagasaki.
- c) Most major hospitals now have a department of nuclear medicine. Applications of nuclear medicine have contributed to the well-being of many Canadians.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) drawings of an accurate half-life graph;
- b) ability to date a fossil from data provided, as in activity 2b;
- c) participation in a class discussion on the pros and cons of using nuclear energy or completion of a written project on nuclear chemistry as outlined in activity 2c.

*See the subsection entitled "Student Activities" on page 5.

6. Safety Considerations

- The regulations from the Atomic Energy Commission concerning the storage and use of radioactive isotopes must be followed.
- For further information on safety, teachers should refer to Part 1, section 9, of this guideline.

7. Possible Extensions

Some students might:

- use Einstein's equation to calculate the energy produced in nuclear fission or the binding energy stored in a nucleus;
- calculate the age of rocks by the decay of potassium 40 to argon;
- participate in a trip to a facility that deals with radioactive isotopes;
- investigate fusion reactions in a star or the hydrogen bomb;
- investigate the use of particle accelerators in nuclear research, especially in the discovery of new elements;
- write nuclear equations for the decay of an isotope by alpha-particle emission, beta-particle emission, and gamma-ray emission.

8. Some Teaching Suggestions

- An activity on half-lives can be simulated by using a pile of coins to represent the atoms of an isotope. The coins can be tossed, and the number of heads counted as decayed atoms and the tails as undecayed atoms. This process can be repeated, with only the remaining undecayed "atoms" being used on each toss. A half-life graph can then be plotted from the data obtained.
- Circular ceramic magnets can be used to simulate (i) protons, alpha particles, and a nucleus to show the instability of large nuclei and (ii) the Rutherford gold-leaf experiment.
- A simplified pamphlet for schools explaining the CANDU reactor can be obtained from Ontario Hydro.
- The historical approach, from Becquerel through to Fermi, can be used to organize the teaching of this unit. Adequate materials will have to be made available in the resource centre.

Optional Unit 5

Locally Designed Unit

Time: 16 hours

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of chemistry not described in this guideline or to incorporate additional objectives that will expand a previous part or parts of the course. The following are examples of new areas or topics that might be considered:

- | | |
|---------------------------|----------------------------------|
| ► Careers in chemistry | ► Fabrics and plastics |
| ► Chemical energy | ► Food chemistry |
| ► Colloid chemistry | ► Industrial chemistry |
| ► Crystals | ► Introductory organic chemistry |
| ► Electrochemistry | ► Photochemistry |
| ► Environmental chemistry | ► Transition elements |

This unit can provide an excellent opportunity for students to engage in independent or small-group study on a topic in chemistry that is of particular interest to them and that is approved, monitored, and evaluated by the teacher. Each activity and experiment should be closely supervised and checked. Care should be taken not to allow the work to overlap with subject matter in other science courses that students are likely to take. The unit could be started after students have had some experiences in the laboratory and are well aware of accident prevention. If a series of short topics is considered, the topics may be fitted into the course schedule from time to time throughout the semester or year.

A locally designed unit is to incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, societal implications, and safety considerations (see section 9 of Part 1 of the guideline). An outline of the unit is to be included in the course of study and kept on file in the school so that it is available to interested students and parents.

Appendixes

Appendixes

- A. Science Courses and Their Course Codes
- B. The Table of Contents of Part 1

Appendix A

Science Courses and Their Course Codes

The secondary school guideline courses in science authorized under this document have the following course codes:

Science, Grade 9, Basic Level	SNC1B
Science, Grade 9, General Level	SNC1G
Science, Grade 9, Advanced Level	SNC1A
Science, Grade 10, Basic Level	SNC2B
Environmental Science, Grade 10, General Level	SEN2G
Science, Grade 10, General Level	SNC2G
Environmental Science, Grade 10, Advanced Level	SEN2A
Science, Grade 10, Advanced Level	SNC2A
Science, Grade 11, Basic Level	SNC3B
Applied Biology, Grade 11, General Level	SBA3G
Applied Chemistry, Grade 11, General Level	SCA3G
Environmental Science, Grade 11, General Level	SEN3G
Biology, Grade 11, Advanced Level	SBI3A
Chemistry, Grade 11, Advanced Level	SCH3A
Science, Grade 12, Basic Level	SNC4B
Environmental Science, Grade 12, General Level	SEN4G
Geology, Grade 12, General Level	SGE4G
Applied Physics, Grade 12, General Level	SPA4G
Environmental Science, Grade 12, Advanced Level	SEN4A
Geology, Grade 12, Advanced Level	SGE4A
Physics, Grade 12, Advanced Level	SPH4A
Technological Science, Grade 12, General Level	STE4G
Biology, OAC	SBI0A
Chemistry, OAC	SCH0A
Physics, OAC	SPH0A
Science in Society, OAC	SSO0A

The following general rules govern science course codes:

- ▶ All science course codes begin with an **S**.
- ▶ **SNC** identifies a course that has only the name “Science”.
- ▶ Where one word other than “Science” describes the course, the first two letters of that word follow the **S** (e.g., **SBI** means “Science, Biology” or simply “Biology”; **SEN** means “Science, Environmental” or “Environmental Science”).
- ▶ Where two words other than “Science” describe the course, the initial letters of those words are used (e.g., **SCA** means “Science, Chemistry Applied” or simply “Applied Chemistry”).
- ▶ The fourth character in the course code, **1**, **2**, **3**, **4**, or **0**, represents Grade 9, 10, 11, 12, or an OAC respectively.
- ▶ The fifth character represents the level of difficulty: **B** for basic, **G** for general, or **A** for advanced.

For further information on course codes, refer to the *Manual for the Common Course Code* (Toronto: Ministry of Education, Ontario, 1986).

Appendix B

The Table of Contents of Part 1

Preface

Introduction

The Parts of the Guideline

Guideline Courses

Superseded Guidelines

A. Goals and Aims

1. The Value and Purpose of Science Education
2. The Goals of Education and the Role of Science
3. The Aims of the Science Curriculum
 - 3.1 The Aims
 - 3.2 The Nature of Science
 - 3.3 Scientific Literacy
 - 3.4 Curriculum Emphases – Blending Curriculum Aims With Content

B. Science Program Framework

4. Science Courses
 - 4.1 The Science Continuum From Kindergarten to OACs
 - 4.2 Levels of Difficulty: Basic, General, and Advanced
 - 4.3 Science Courses and Credits
 - 4.4 Units of Study Within Each Course
 - 4.5 Recommendations Regarding Course Selections
5. Teaching Policy
 - 5.1 Content and Process
 - 5.2 Components in Each Unit of Study
 - 5.3 Teaching Policy for All Science Units
 - 5.4 Time Allocations for Each Unit
 - 5.5 Locally Designed Units

5.6 The Grade Placement and Naming of Local Science Courses

5.7 Overall Policy for Science Courses

C. Special Features of the Science Program

6. Considering the Science Student
 - 6.1 The Image of the Successful Science Student
 - 6.2 Program Adaptations for Exceptional Students
 - 6.3 Individualized Instruction
 - 6.4 Life-Management Skills
 - 6.5 Employment Awareness
 - 6.6 Sex Equity
 - 6.7 Multiculturalism
7. Language and Science
 - 7.1 Language Skills
 - 7.2 Assignments and Evaluation
 - 7.3 English Vocabulary in French-Immersion Science Courses
 - 7.4 Immigrant Students
8. Measurement
 - 8.1 Estimation
 - 8.2 Metric Units and Physical Quantities
 - 8.3 Accuracy and Precision
 - 8.4 Formats in Solutions to Problems
9. Safety
 - 9.1 Safety in the Laboratory
 - 9.2 Some Recommended Safety Procedures
 - 9.3 Animal Care in Science Courses
 - 9.4 The Safe Use of Plants

- 10. Values in Science Education
 - 10.1 The Role of Values Issues in Science Courses
 - 10.2 Handling Sensitive Issues

D. Implementation

- 11. Curriculum Planning and Staff Development
 - 11.1 Policy Planning at the Board Level
 - 11.2 Program Planning at the School Level
 - 11.3 Course Planning at the Teacher Level
 - 11.4 School-Board Curriculum Documents
 - 11.5 Staff Development
- 12. Resources
 - 12.1 Science Laboratories and Equipment
 - 12.2 Library Resource Centres
 - 12.3 Textbooks and Learning Materials
 - 12.4 Calculators
 - 12.5 Computers
 - 12.6 The Scientific Community
- 13. Modes of Delivery
 - 13.1 Bilevel and Multigrade Classes
 - 13.2 Co-operative Education
 - 13.3 Program Packages
 - 13.4 Adult Education
 - 13.5 Independent Learning Centre
 - 13.6 Specialized Schools
- 14. Evaluation
 - 14.1 Evaluating Guideline-Implementation Progress
 - 14.2 Evaluating Student Achievement
 - 14.3 Self-Evaluation of Teacher Performance
 - 14.4 Evaluation of Program Effectiveness

Appendixes

- A. Science Courses and Their Course Codes
- B. Physical Quantities
- C. Metric Editorial Practice
- D. Some Poisonous Plants
- E. Some OAIP Instrument Types and Learning Domains



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